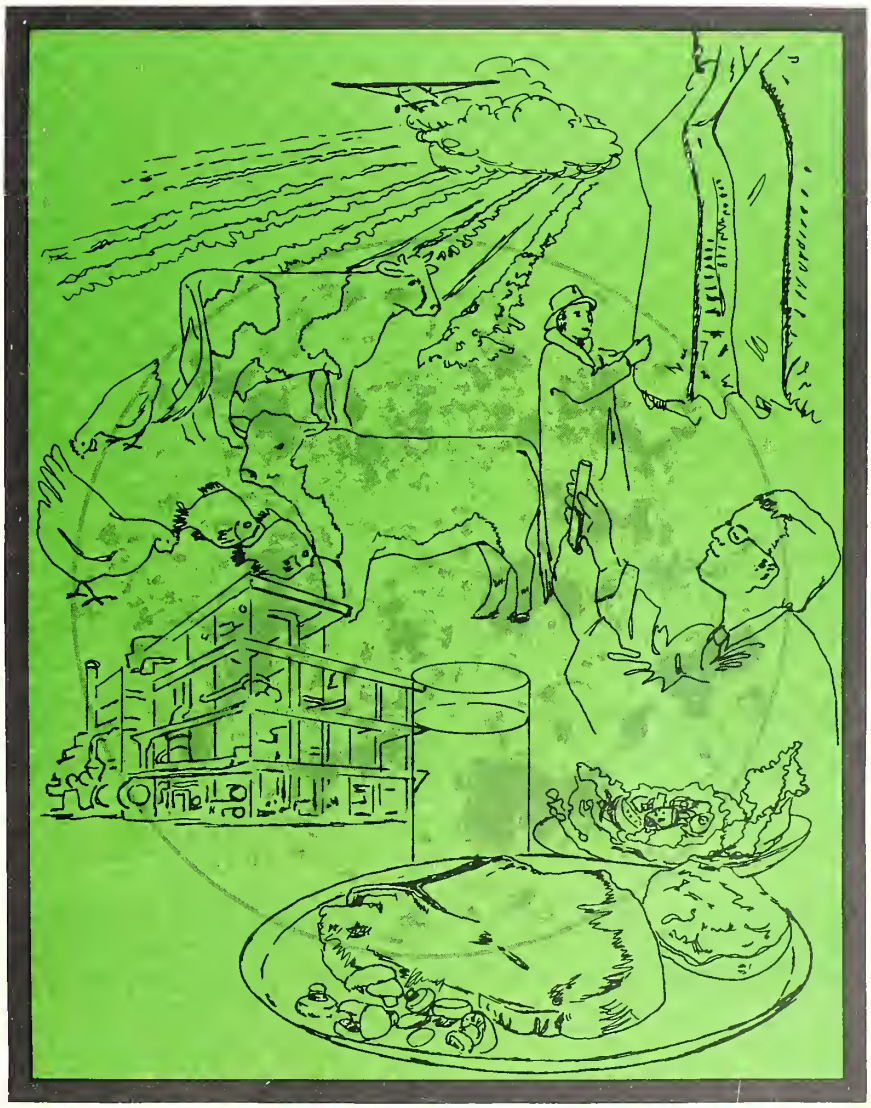
A Program Of Research For The Southern Region In

FOOD SAFETY



Prepared By A Joint Task Force
Of The Southern Region Agricultural Experiment Stations
And The United States Department Of Agriculture Personnel

First Revision 1974 - 1975

FOOD SAFETY AND PROTECTION RESEARCH NEEDS

IN THE

SOUTHERN REGION

A Report of the

FOOD SAFETY TASK FORCE

for the Southern Region

Agricultural Experiment Stations

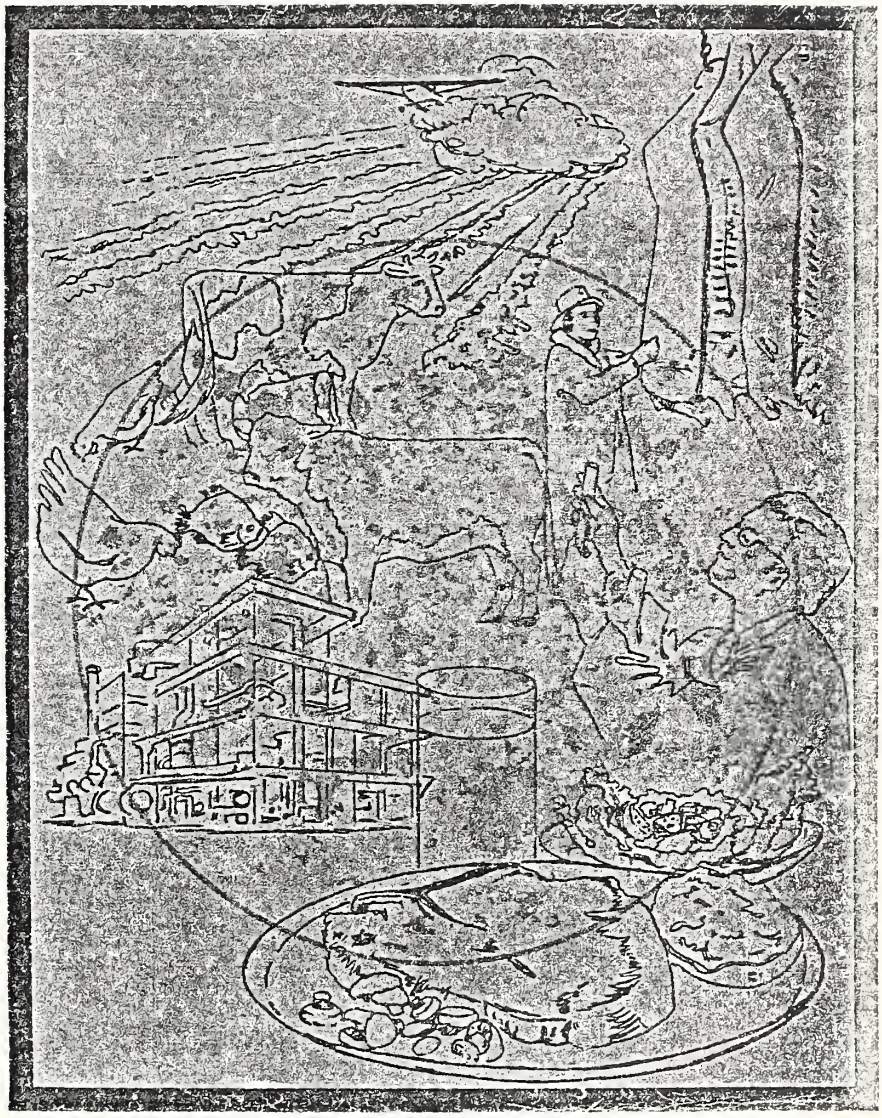
and the

United States Department of Agriculture

First Revision - 1974-75

A Program Of Research For The Southern Region In

FOOD SAFETY

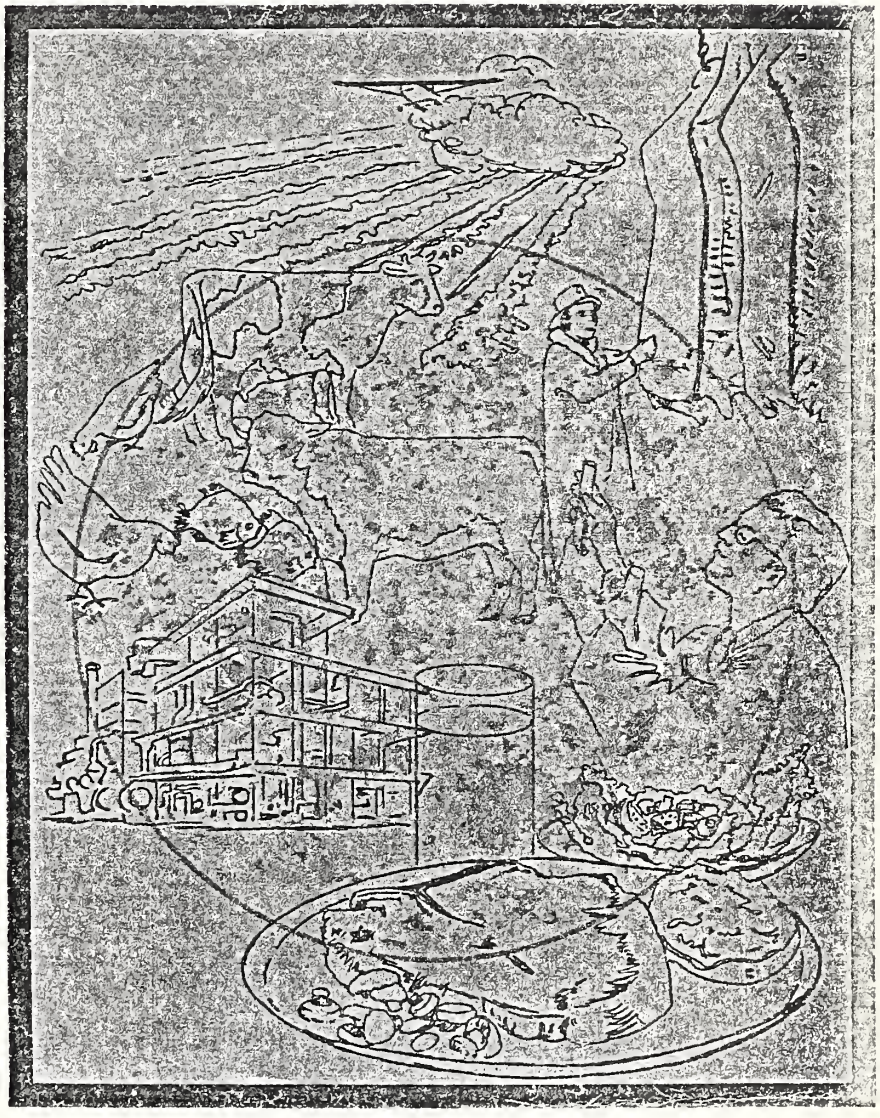


Prepared By A Joint Task Force
Of The Southern Region Agricultural Experiment Stations
And The United States Department Of Agriculture Personnel

1972

A Program Of Research For The Southern Region In

FOOD SAFETY



Prepared By A Joint Task Force

Of The Southern Region Agricultural Experiment Stations

And The United States Department Of Agriculture Personnel

1972

FOOD SAFETY AND PROTECTION RESEARCH NEEDS IN THE SOUTHERN REGION

A Report of the

FOOD SAFETY TASK FORCE

for the Southern Region

Agricultural Experiment Stations

and the

United States Department of Agriculture

1972

CONTENTS

PAGE

INTRODUCTION

No country in the world produces, distributes and processes its food for a smaller percentage of the consumer's income than is done today in the United States. Less than 17% of the consumer dollar is spent for food in the U.S. whereas about 40% is spent in Russia, and as much as 80% is spent in India. Most U.S. consumers are unaware they are the chief benefactors of the developments in agricultural production, processing and marketing derived from technological advances.

The routine of the U.S. housewife and mother has changed markedly through the years. With the introduction of partially prepared, processed (fabricated) and convenience foods she spends less and less time in meal preparation and therefore has more time to satisfy activities and interests outside the kitchen. She has elected to purchase more and more processed foods and also more and more built-in convenience in the form of food preparation, packaging and distribution.

In responding to these demands, agricultural production has become highly specialized with more farming operations consisting of larger acreages of one or two crops. Today's agriculture benefits from the economies of large scale production and improved technology. Furthermore, these production developments are often integrated with processing and marketing activities. As a result the consumer may completely lose the feel and appreciation of the food production

sources and requirements. Under the U.S. system, the consumer is almost completely dependent upon the producer, processor and handler for the safety of the food products consumed. The complete reliance and dependence upon others for the quality and purity of the food served and eaten by the American family makes the problem of food safety a prime responsibility for producer, processor and distributor alike.

In an attempt to examine the overall significance of this problem, the Agricultural Experiment Station Directors of the Southern Region at their meeting in April, 1971, elected to activate a Regional Food Safety and Protection Task Force. A group of scientists was asked to meet and examine the food safety and protection problems peculiar to the crops and commodities grown in the South, to delineate the research needs, and to make recommendations as a basis for better planning and integration of research activities by state universities and federal agencies. From this activity a report was issued in 1972, "A Program of Research for the Southern Region in Food Safety".

In January of 1974, a second Task Force was convened under the auspices of the Southern Regional Research Committee in an expanded state-federal planning effort involving the State Agricultural Experiment Stations and the Agricultural Research Service, U.S.D.A., in the Southern Region. The second Task Force was asked to review the original report, retain valid research needs and to identify any

new problems needing research effort.

The membership of the present Task Force is listed in the revised report and includes representation from all states in the region except Oklahoma, Mississippi and Puerto Rico. The Task Force organized itself into four major sub-committees, Food Protection, Food Processing and Manufacturing, Food Handling, and Mycotoxins. These sub-committees first designated important subject matter areas within the limitations of their sub-committee responsibilities. Following this, the most pressing research needs were examined and judged as to priority and estimated manpower required for each subject matter heading. The specific research needs are described by title, situational statement, a statement of the objectives of the research, the committee's suggestions as to the research approach which should most logically be followed, a statement concerning regional needs where these are felt to exist and suggestions when pertinent about needs for applying information already known but not properly used. Also presented as it relates to each subject matter area is a resume of the present project base showing SMYs of work within the Southern Region.

All of this information is now assembled as a guide to administrators of state universities and federal agencies, to food industries, and to technical faculty and staffs of these institutions and agencies, so that resources and inputs into research in food safety may be placed in areas where the greatest needs exist. Further, this committee will continue to observe research on food safety within

the region so that joint planning may be encouraged and unneeded duplication eliminated or avoided. It is proposed that this document will become a part of the joint Regional and National planning effort for agricultural research.

RESEARCH OUTLOOK

We live in an age in which man is exposed to an increasing number of hazards to his health and safety. Based upon past experiences, the public still assumes that agricultural production, processing and marketing industries will continue to produce and market food that is wholesome, safe from harmful pesticide residues, disease agents and toxic substances, and high in nutritional value. A greater variety of food which is carefully produced, processed and marketed, and is of the highest quality, safety and wholesomeness is available to the consumer in America than anywhere else in the world.

Public confidence in this food supply must be maintained. A sudden loss in confidence in the safety and wholesomeness of a food crop or food product can ruin a production or processing and market-industry. Past incidents of recall of well-known commercial brands of mushrooms and tuna suspected to contain botulinal organisms, swordfish containing excessive amounts of mercury, poultry containing PCBs, baby foods containing cockroach fragments, peanuts, pecans and other raw agricultural products contaminated with mycotoxins or agricultural chemicals used in production or processing have shaken consumer confidence in the safety of the foods available to them. Intensive research is needed to reduce the occurrence of these hazards and readily assure the safety and wholesomeness of foods before delivery to the consumer. A continuing,

expanded and responsive program of food safety research will identify and solve these emerging problems and maintain public confidence. Furthermore, additional research is needed to provide a basis for the regulatory and control activities of governmental agencies, to protect the food industries and the public from disastrous consequences arising from outbreaks which threaten the health and safety of the public and the future of the industries. The benefits which accrue to mankind will be worth the effort required.

The purpose of this report is to identify the needs for research in food safety and protection. Major emphasis is placed upon the needs of the region, although it is obvious that many of the problems are national in scope and the information will become a part of the national agricultural research planning program.

As the food production, processing, and marketing industries grow, the problems associated with these activities become more complex and intense. Agricultural production tends to occur in areas distant from the centers of population, consequently more foods will be processed and changed in form to facilitate their protection and delivery to consumers. Transportation involves greater distances, longer storage and more temperature control. Consumers demand more services, individually packaged units, and greater variety and convenience. Shortages of energy and petrochemicals now demand new efficiencies and conservation.

methods in food production and processing. Many of these changes in technology of production, processing and delivery of food carry with them attendant potential hazards to food safety.

Food safety problems may be defined in terms of the nature of the hazard involved, source or origin of the hazard, or in terms of the biological response of the target population. For example, Dr. Virgil Wodicka, Director of the Bureau of Foods of the Food and Drug Administration, has arranged the hazards as follows: (a) microbiological hazards, (b) nutritional hazards, (c) environmental contaminants (pollutants), (d) natural toxicants, (e) pesticide residues and (f) food additives. Hazards to the food supply may be viewed from the standpoint of source or origin in (1) natural (infections, toxic chemical components) or (2) man-made (agricultural chemicals, food additives, packaging materials, changes induced by processing--accidental or intentional). Still another approach involves consideration of the biological response of the target population in animals, the aged, infants, the infirm, expectant mothers or other especially susceptable groups.

Other views would give consideration to the needs for regulatory and control activities, the need for better methodology, particularly more rapid and dependable techniques and the need for basic information on incidence, characterization, biological effects and metabolic mechanisms.

Specific problem areas were identified and assigned priority values under each subject matter area listed on Page vii.

Special attention was given to identifying the most pressing problems as seen by the Task Force. These lists are by no means all inclusive.

The effects of changing technology in agricultural and aquatic production combined with the need to make effective and efficient use of natural resources (soil and water) and the need to protect the environment and the consumer, make it necessary to continuously evaluate the impact on food safety of agricultural products. For example, wastes, sometimes disposed of in the soil or water resource, may contain heavy metals and other compounds toxic to plants and animals and ultimately to humans. Fertilization practices, particularly nitrate and phosphate fertilizer applications, have come under close scrutiny. Genetic modifications leading to new plant varieties must be evaluated with regard to impact on safety as well as yield. Antibiotics and growth regulators may not be used in animal feed without regard to possible occurrence of residues on the edible products. New production practices such as mechanical harvesting, with use of abscission chemicals must be assessed for future impact on foods and products.

Centralization of food processing and manufacturing operations brings with it greater risks since a single error may have widespread impact on the industry and affect the health and safety of large numbers of consumers many miles distant from the plant. Location of the food production areas, frequently remote from the concentrations

of consumers, necessitates processing, storage and distribution of large quantities of foods. Packaging and refrigeration add to the costs of food and provide additional potential problem sites. Quality control, particularly quality assurance with respect to safety and wholesomeness, under these condition assumes a greater importance. Development of our food sources and new food forms and types (fabricated or formulated) brings with it the range of problems of safety associated with ingredients, formulation, process, final product, packaging, distribution and preparation for consumption and serving.

A large number of people lack an adequate knowledge about food safety. Foods are frequently improperly handled because people fail to see a close relationship between these activities and the ultimate quality and safety of the food consumed. Outbreaks of food-borne diseases involving people continue to increase in frequency and number. Knowledge regarding the occurrence and importance of mycotoxins in the food is just beginning to unfold. There is an urgent need to intensify the research effort on microbial and viral contaminants of foods. Basic information is needed to characterize bacterial toxins and ways to eliminate the hazard from the food chain.

Climatic conditions unique to the Southern Region tend to magnify certain food safety problems. For example, the generally higher levels of temperature and humidity encountered directly or

indirectly affect fertilization rates and leaching of nutrients from the soil; reliance on chemical means for disease and insect control on food crops and animals; the occurrence and extent of fungi and associated mycotoxins and the general level of sanitation required in handling foods. Currently the South is shifting toward more crop and livestock production. Mold growth in certain food products or commodities (peanuts, cottonseed, pecans, poultry), grown almost exclusively in the South, presents special problems.

It is self-evident that the application of technology and effective utilization of resources by the food production, processing and marketing industries has contributed to the economic development of the Southern Region while furnishing a safe, wholesome and low-cost food supply for the consuming public. It is equally self-evident that the continued development and further realization of the growth potential of the food production, processing and distribution industries depends upon discovery and application of new knowledge and technology to meet the increasingly discriminating and varied demands of the consumer and upon maintenance of public confidence in the safety of foods. Furthermore, attainment of this needed new knowledge and technology will be realized only through a concerted research effort that makes maximum use of research creativity, multidisciplinary approaches and the "systems" concept in solving the problems facing these industries. Food safety problems cannot be resolved in a highly structured research framework in which

investigations on production are separated from handling, storage, processing and marketing considerations. Research on food safety problems demands a degree of integration that has yet to be achieved in much agricultural research.

MEMBERS

Southern Regional Food Safety and Protection Task Force

I. Food Protection (Production) Sub-committee

Chairman

Dr. T. L. Goodwin
Professor, Poultry Products
Department of Animal Science
University of Arkansas
Fayetteville, Arkansas 72701

Secretary

Dr. A. B. Childers
Assistant Professor, Food Hygienist
Department of Veterinary Public Health
Texas A & M University
College Station, Texas 77843

Dr. Alexander C. Keyl
Chief, Pharmacology Laboratory
R. B. Russell Agricultural Research Center
Box 5677
Athens, Georgia 30604

Dr. Zane F. Lund
Acting Research Leader
USDA - Agricultural Research Service
Agronomy Department
Funchess Hall
Auburn University
Auburn, Alabama 36830

II. Food Processing and Manufacturing Sub-Committee

Chairman

Dr. R. A. Dennison
Professor and Chairman
Food Science Department
University of Florida
Institute of Food and Agricultural Sciences
Gainesville, Florida 32611

Secretary

Dr. James J. Spadaro
Acting Chief
Engineering and Development Laboratory
USDA - Agricultural Research Service
Southern Regional Research Center
New Orleans, Louisiana 70179

Dr. Robert E. Berry
Laboratory Director
Citrus and Subtropical Products Lab
USDA - Agricultural Research Service
P. O. Box 1909
Winter Haven, Florida 33880

Dr. Michael G. Johnson
Assistant Professor, Food Science and Microbiology
Department of Food Science
Clemson University
Clemson, South Carolina 29631

Dr. Bruce J. Lime
Research Leader
USDA - Agricultural Research Service
Southern Region
Subtropical Texas Area, P. O. Box 388
Weslaco, Texas 78591

Dr. Arthur J. Mercuri
Chief, Animal Products Lab
USDA - Agricultural Research Service
R. B. Russell Agricultural Research Center
P. O. Box 5677
Athens, Georgia 30604

Dr. W. A. Sistrunk
Professor
Department of Horticultural Food Science
University of Arkansas
Fayetteville, Arkansas 72701

Dr. William M. Walter, Jr.
Research Chemist
USDA - Agricultural Research Service
Food Science Department
North Carolina State University
Raleigh, North Carolina 27607

III. Food Handling Sub-Committee

Chairman

Dr. Richard V. Lechowich
Professor and Head
Department of Food Science and Technology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Secretary

Dr. John A. Koburger
Associate Professor, Food Microbiologist
Department of Food Science
University of Florida
Institute of Food and Agricultural Sciences
Gainesville, Florida 32611

Dr. Robert M. Grodner
Professor, Food Scientist
Department of Food Science
Louisiana State University
Baton Rouge, Louisiana 70803

Dr. Bruce E. Langlois
Associate Professor, Animal Scientist
Department of Animal Science
University of Kentucky
Lexington, Kentucky 40506

Dr. W.W. Overcast
Professor
Food Technology and Science Department
University of Tennessee
Knoxville, Tennessee 37901

Dr. Marvin L. Speck
WNR Professor, Food Science and Microbiology
Department of Food Science
North Carolina State University
Raleigh, North Carolina 27607

IV. Mycotoxins

Chairman

Dr. John C. Ayres
Professor
Department of Food Science
University of Georgia
Athens, Georgia 30601

Secretary

Dr. Urban L. Diener
Professor, Plant Pathologist
Department of Botany and Microbiology
Auburn University
Auburn, Alabama 36830

Dr. Harold P. Dupuy
Research Chemist
Southern Regional Research Center
USDA - Agricultural Research Service
P. O. Box 19687
New Orleans, Louisiana 70179

Dr. Harry W. Schroeder
Research Leader
USDA - Agricultural Research Service
P. O. Box E.D.
College Station, Texas 77840

General Secretary:

Dr. Robert E. Berry
Laboratory Director
Citrus and Subtropical Products Lab
USDA - Agricultural Research Service
P. O. Box 1909
Winter Haven, Florida 33880

Representative for Cooperative States Research Service; USDA:

Dr. R. G. Garner
Director, Food Science Programs
Cooperative States Research Service
United States Department of Agriculture
Washington, D. C. 20250

Administrative Advisor for Southern Agricultural Experiment Stations:

Dr. John W. Sites
Dean for Research and Horticulturist
Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida 32611

Administrative Advisor for Agricultural Research Service; USDA:

Mr. Dean F. Davis
Area Director
USDA - Agricultural Research Service
1700 S.W. 23rd Drive
Gainesville, Florida 32604

Priorities and Estimated Manpower Requirements
For
Food Safety Research Needs

Title	SMYs*	Priority
I. Food Protection (Production)		
A. Soil and Water		
Microbiological contamination of soil and water from feedlots and poultry wastes, and the utilization of animal wastes as a source of animal feed.....	25.0	1
Accelerating degradation of polychlorinated biphenyls (PCBs) and other chlorinated pesticides from beef, dairy and poultry animals.....	20.0	2
Animal wastes fertilization of forage crops as related to soil chemistry, forage quality, and animal health.....	50.0	3
Pesticide residues on fruits and vegetables.	20.0	4
Occurrence of heavy metals in the environment.....	20.0	5
Effect of herbicide applications on nitrogen levels of food crops.....	4.0	6
Effect of sources and rates of release of fertilizer N on the inorganic composition and alkaloidal content of crops.....	30.0	7
Rates of methemglobin formation in relation to nitrate/nitrite levels in diet of experimental animals.....	2.0	8
B. Toxicants in Food and Feed		
Isolation of phytoaleximes and glycoalkaloids from eggplant, potatoes, watermelons, tomatoes and other plants and study of their pharmacological and toxicological effects...	15.0	1

*The SMYs listed represent the committee's best judgment concerning the number of man years (SMYs) required to complete the research within five years.

	SMYs	Priority
Develop plant breeding programs to reduce or eliminate naturally-occurring toxicants in food and feed crops.....	10.0	2
C. Aquatic Foods		
Health-related aspects of chemical, microbial and other biological factors in commercial seafoods.....	50.0	1
Health-related aspects of developing commercially valuable products from non-utilized aquatic products.....	15.0	2
Public health hazards of aquatic species grown in confinement.....	25.0	3
II. Food Processing and Manufacturing		
Methods to minimize the dissemination of salmonellae, and other harmful micro-organisms during processing of poultry and red meat products.....	35.0	1
Systems to minimize microbial or chemical contaminants while optimizing reuse and recycling of processing water in food processing plants.....	110.0	2
Chemical and microbiological problems associated with the use of nitrate and nitrite.....	15.0	3
Improvement in pre-processing treatments of plant and animal raw food materials.....	80.0	4
Control of *Clostridium botulinum*, *Vibrio parahaemolyticus* and other pathogens in pasteurized, smoked and preserved aquatic foods.....	45.0	5
Identification and reduction of natural toxicants and of environmental and microbiological contamination of plant products.	30.0	6

	SMYs	Priority
Community canning centers and home preservation and storage of food.....	10.0	7
Assure safety of animal feeds and food comprised of by-products and waste from food processing.....	100.0	8
Thermal requirements for safe processing of canned Southern foods.....	20.0	9
Injury phenomena of microorganisms caused by food processing methods.....	25.0	10
Pathogen survival in fermented versus directly acidified foods of animal origin and safety of such foods when pickled.....	40.0	11
Potential health hazards from the use of natural and synthetic food additives.....	20.0	12
Formation of toxic constituents during processing and storage of foods.....	30.0	13
Potential microbial and toxic hazards of engineered foods.....	20.0	14
Microbiological contamination from spices, herbs and other minor ingredients in convenience foods.....	20.0	15
The influence of packaging materials on the composition and safety of foods.....	10.0	16
Intermediate moisture foods.....	20.0	17
III. Food Handling and Food Service		
Development of new methods for the effective dissemination of existing technical information.....	45.0	1
New and improved methods for the detection of public health hazards.....	35.0	2

		Priority
Safety hazards in the handling of raw foods.	10.0	3
Control of food safety hazards in processed produts which result from handling practices during and after processing.....	30.0	4
Viruses in foodstuffs.....	10.0	5/

IV. Mycotoxins

Aflatoxin and related mycotoxins in processed food products.....	50.0	1
Aflatoxin and related mycotoxins in livestock and poultry feeds.....	50.0	2
Mycotoxin methodology.....	80.0	3
Detection and control of aflatoxin and other mycotoxins in tree nut crops.....	15.0	4
Mycotoxins in milk, cheese, and aged cured meats.....	15.0	5
Fusarium mycotoxins in corn and other livestock feeds in the South.....	30.0	6
Penicillium toxins in foods and feeds.....	40.0	7
Patulin in food and feed products.....	15.0	8
Furanoterpenoid toxins in sweet potatoes....	20.0	9
Phototoxins in vegetables and grasses.....	10.0	10
Ochratoxins and related mycotoxins in foods and feeds.....	10.0	11
Mushroom toxins.....	10.0	12

Southern Region Task Force Report on

FOOD SAFETY AND PROTECTION

I. Food Protection (Production)

A. Soil and Water

Environmental contaminants are either natural or man-made substances that have inadvertently become included in food and may produce undesirable effects in man and animal. Many of the food hazards can be attributed to previous association with soil and/or water. One important problem area associated with modern agricultural practices is the source and rates of commercial fertilizers that are used in great quantities in order to produce the highest possible yields. Certain susceptible crops accumulate high levels of nitrate-N, resulting in possible health hazards to humans (particularly infants) and to ruminant livestock due to the consumption of water and plant materials containing excessive nitrate content. In addition, the use of certain herbicides may detrimentally increase nitrogen and alkaloidal compounds in certain food crops. Heavy metals, occurring naturally in the soil where food crops are grown, present a potential risk through their possible adverse effect on essential mammalian enzyme systems. Mercury contamination of fresh and salt water food items is widespread in the Southern Region as well as the United States in general. Runoff from concentrated cattle feedlots and poultry operations may contaminate surface and even ground water supplies. The microbiological content of these wastes is often high enough to create a public health problem in the vicinity of these operations. An additional threat to the environment from these activities is an excess of nitrogen in the soil that becomes readily available to the feed and water of grazing animals and to food crops. High quality irrigation water is essential in order to maintain quality, uniform growth and high yields in our food production.

1. Title: Microbiological contamination of soil and water from feedlots and poultry wastes, and the utilization of animal wastes as a source of animal feed. SMYs 25.0 Priority 1 .

Situation: It is estimated that 1.7 billion tons of animal waste are produced annually in the United States with approximately 50% of this waste produced by animals in confinement. These large quantities of wastes are difficult to dispose of and result in problems of flies, odors, and pollution of water supplies. Run-off from feedlots and poultry operations may contaminate with microorganisms infectious to man and animals the water supplies and soil used to grow food crops.

Animal wastes might be recycled as a source of nutrients. However, the problems of microbiological content and drug and pesticide residues must first be solved. Sufficient heat treatment to make animal wastes microbiologically acceptable is expensive and may reduce the nutritive value. Questions have arisen as to the possible buildup of resistance by microorganisms to antibiotics when waste products are recycled as feed ingredients.

Pesticide residues in waste products used as feed ingredients could possibly result in higher levels of pesticides in animal tissues used for food. Contamination of ground and irrigation water with excess nitrogen must be considered when disposing of large quantities of animal waste.

Objectives:

a. To evaluate the degree of contamination of ground water by nitrogen, chemical compounds, and microorganisms resulting from animal wastes and to develop means of reducing these hazards by more effective disposal of these wastes.

b. To evaluate production methods that would convert animal wastes to a suitable feedstuff by determining antibiotic resistance of microorganisms in animal wastes, the persistence of pesticides in these wastes, and treatment methods which would eliminate undesirable microorganisms.

Research Approach:

a. Determine ways of collecting and treating runoff water to reduce its microbiological content and to reduce the amounts of nitrogen or other undesirable chemicals reaching surface and ground water supplies.

b. Measure the transfer of microbial and chemical residues to man via foods grown either on contaminated soil or derived from animals consuming feedstuffs grown on contaminated soil.

c. Evaluate various methods for treating animal wastes, such as ensilaging, chemical or heat sterilization; drying, pelleting or extruding to produce a finished product with adequate nutritive values and one that is free from harmful microbial or chemical residues.

d. Determine the transfer of antibiotic resistance of micro-organisms to man through animals receiving these antibiotics in the feed.

e. Analyze the cycling of nitrogen through food, animal feed-stuffs, atmospheric deposit, surface and ground water and soil.

Regional Needs and/or Application: The Southern Region has become a large producer of poultry and livestock and with this increased production goes the problem of waste disposal. The traditional practice of applying this material back on the land has created numerous problems. Development of techniques for utilizing animal wastes as feed ingredients and for preventing their contamination of soil and water would prove very beneficial.

2. Title: Accelerating degradation of polychlorinated biphenyls (PCBs) and other chlorinated pesticides from beef, dairy and poultry animals.
SMYs 20.0 Priority 2 .

Situation: Although not pesticides per se, the polychlorinated biphenyls (PCBs) have recently been found in many environmental samples being screened for chlorinated pesticides including food, water and livestock feed. PCBs seem to enter the environment from discarded printing inks, carbon paper, rubber tires, plasticizers, etc. PCBs resist normal environmental degradation, are insoluble in water but highly soluble in lipids. Therefore, it is inevitable that PCBs would be concentrated in biological systems since they possess all the characteristics of the persistent chlorinated insecticides. Current knowledge as to their mammalian toxicity requires expansion, but from limited information it appears that the PCBs in general are somewhat less toxic to mammals than DDT or its metabolites.

Considerable research has already been undertaken in attempts to accelerate the biological degradation of certain persistent chlorinated insecticides; particularly in meat, dairy and poultry products since these items apparently contribute the largest amount of chlorinated pesticide residues to the U.S. diet. It has been shown that energy deprivation, feeding of charcoal and barbituates, and injection of anticonvulsants and anabolic hormones tend to accelerate residue depletion in animal systems. However, preliminary work indicates that certain of these methods (charcoal and barbituates) do not appear to accelerate the depletion of PCBs in mammalian systems. Several recent condemnations which resulted in the removal of poultry and dairy products from the market, emphasize the needs for added research to find practical means of accelerating the biodegradation of PCB residues inadvertently present in animal systems.

Objective: Develop effective means for accelerating the biological degradation of illegal residues of PCBs and other chlorinated chemicals in beef and dairy cattle and in poultry prior to the time their by-products affect man's food.

Research Approach:

a. Use of hyper metabolic agents on cattle and poultry to accelerate PCB depletion by increasing body fat metabolism.

b. Develop methods for reducing or eliminating PCB levels in animal feeds.

Regional Needs and/or Application: Producers of animal products, particularly poultry, in the Southern Region have recently experienced condemnation of their products due to excessive residues of PCBs and persistent chlorinated pesticides. The development of practical methods to accelerate biological degradation of these persistent residues in poultry and cattle tissues would be of considerable benefit to agricultural producers.

3. Title: Animal wastes fertilization of forage crops as related to soil chemistry, forage quality, and animal health.
SMYs 50.0 Priority 3 .

Situation: Among the suggestions for disposal of animal wastes from feedlots, poultry houses, etc. incorporation in soil has received serious consideration. This would mean mixing many tons of waste with the top one to three feet of soil. Such quantities would be expected to have considerable influence on the soil, pH, organic matter content, relative abundance and availability of various plant nutrients, water holding capacity and other factors. This would in turn influence the quantity and quality of forage produced. In addition to chemical factors, the manures would or could contain pathogenic organisms which could infect animals grazing or otherwise using the forage. Such treated land could serve as a reservoir, particularly of enterobacteria, which could be passed on to humans.

Disposal of animal wastes on grasslands is a system of choice for many poultry producers in the south because it provides more flexibility than application of wastes on cultivated lands where wastes must be applied either before or after the crop season (with the exception of slurry irrigation). Most grass sods support manure spreaders immediately after storms, whereas tilled lands do not. Although grass-cattle systems yield a more modest return than many cultivated crops, they are an excellent managerial choice for many producers because timing or spreading operations and less exacting labor demands can be matched to poultry production operation demands. However, the incidence of such animal health problems as grass tetany, nitrate toxicity, fescue toxicity, and fat necrosis have been observed to increase where poultry litter has been applied at heavy rates for a long time to fescue pastures. It is recognized that fescue foot toxicity may be due to fungi. Intensive poultry production in Northwest Arkansas, Northern Mississippi, Northern Alabama, North Carolina, and North Georgia, where the predominant improved perennial grass is tall fescue, makes animal health problems in these areas be of economic importance. Unpublished evidence from the Southern Piedmont Conservation Research Center suggests that these problems can also occur in fescue pastures heavily fertilized with commercial fertilizers and are related to plant nutrient input rather than poultry manure, per se. There is a reason to suspect that grass tetany and nitrate toxicity hazards will exist with other cool-season forages under similar ecosystem management.

Objective: To establish criteria and practices for management of heavily animal waste fertilized pastures which promote good grass and animal production with a minimum of animal health problems and to prevent the pollution of soil, water, and crop resources.

Research Approach: Well-designed field and laboratory experiments are needed which reveal the principles involved in the safe use of animal waste under a variety of grazing ecosystems. Such research should evaluate the effects of types of wastes, rate of application, soil types, types of forage, and animal management on the performance and health of grazing animals. The approach should involve soil-plant-animal relationships in a multi-disciplined effort in which maintenance and/or improvement of environmental quality is an important consideration. Methods and techniques for preventing animal health problems through such potential means of supplemental soil and/or plant fertilization, animal supplementation, pasture crop selection and management should be evaluated to provide systems where maximum utilization of animal waste can be made consistent with minimum hazards to animal health, animal performance, and environmental quality. The bacteriological aspect of the problem could be initially approached by small scale studies to determine persistence of pathogens under expected field conditions. When the chemical and physical tests go to the field, they should include treatments which are seeded with pathogens; livestock should be grazed on the treated fields.

Regional Needs and/or Application: With increasing pressure from environmentalists throughout the South there will be need to find means of disposal of solid wastes from feedlots and poultry growing and liquid wastes from swine production and from dairies. To these may be added various other sources of waste. Disposal on land seems to be one of the more promising means of disposal. It thus becomes vital to know the effect of the practice on the soil and upon animals which may be pastured on the land.

The importance of tall fescue as a well-adapted grass to much of the Southern Region, the importance of the poultry industry and the magnitude of the animal waste problem in the South, the importance of the cattle industry in the South, and the demonstration that such animal health problems occur in N-abundant ecosystems suggest that a thriving growing agricultural economy needs solutions which permit maximum utilization of plant nutrients in animal wastes in producing grass, and in systems which convert this grass to beef safely and efficiently. For example, current recommendations are to limit fescue pasture fertilization to less than 4 tons per acre per year, yet research results show that maximum fescue growth occurs at higher rates (up to 16 tons/acre/year). If methods are developed to safely utilize the extra grass, the benefits are two-fold, i.e. higher per acre production and lower poultry waste disposal costs (transportation costs are a major factor in cost of land utilization systems of waste management).

4. Title: Pesticide residues on fruits and vegetables.
SMYs 20.0 Priority 4 .

Situation: Production of fruits and vegetables is dependent upon control of diseases, insects, and weed pests. Chemical control has been most efficient in most cases. Many of the chemicals used are toxic to warm-blooded animals and, in many cases, the effects of continued ingestion of small quantities of these pesticides is not known. In some instances accurate evaluation of the quantity of the specific pesticide is difficult to determine. On the other hand, harmless chemicals that are useful in food production may be eliminated because we cannot accurately measure them or determine their effects. Specific information would enable regulatory agencies to make rational decisions on the use of pesticides and prevent "panic" legislation.

Objective: The increasing use of pesticides requires a careful monitoring of food products. These tests must be accurate, quick, meaningful, and inexpensive. The consumer must be protected from the use of dangerous chemicals. However, the food producer must have pesticides available to help him maintain the production necessary to feed our burgeoning world population.

Research Approach:

a. Develop quick, reliable, and inexpensive automated procedures for routine analytical purposes.

b. Devise means for detecting quantitatively amounts of new pesticides or residues that may have implications for health of warm-blooded animals.

c. Evaluate tolerance levels to new chemicals.

d. Evaluate long-time effects of pesticide residues on warm-blooded animals.

Regional Needs and/or Application: Food production in the South has been increasing. Mild winters enable Florida and Texas to supply the fresh vegetable market of northern states in mid-winter. The next tier of states produces vegetables and fruits for early spring consumption in many parts of the U.S. In addition, much fruit and vegetable production in the South goes into processed foods. Many of the fruits and vegetables entering the fresh market do not receive the cleaning and inspection given to processed foods. This is a large potential area for problems of pesticide residues, and monitoring of this area of production needs to be done.

5. Title: Occurrence of heavy metals in the environment.
SMYs 20.0 Priority 5 .

Situation: Although heavy metals, except for mercury, are not currently considered as a problem in food safety and protection, they do present a severe potential risk that merits consideration. Heavy metals can adversely affect the metabolism of all living organisms through moderation of enzyme systems. Mercury specifically has been demonstrated to be a carcinogen, mutagen, and teratogen to high animals depending on the chemical formulation and dosage.

Atomic absorption spectrophotometry represents a rapid and sensitive method for the detection of heavy metals in the environment. This technique has been used to survey the total intake of metal. Composites of the twelve major food classes (dairy products, meats, cereals, potatoes, leafy vegetables, legumes, root vegetables, garden fruits, fruit oils, fats, and sugar products) as normally prepared by the housewife were analyzed for Cu, Pb, Zn, Mn, Cd, Cr, Co, Hg, and Fe. The metal concentrations (fresh weight basis) in the individual food classes were low: 3.8 ppm Cu in dairy products, 0.5 ppm Pb in leafy vegetables, 36.6 ppm Zn in meats, 10.2 ppm Mn in cereals, 0.14 ppm Cd in cereals, 0.32 ppm Cr in garden fruits, 0.10 ppm Co in sugar products, 27.1 ppm Fe in meats and $\geq$0.02 ppm Hg in all classes. Several trace metals (Cu, Mn, Zn and Co) are essential to vital processes.

On the basis of this analysis, the dietary intake of lead is lower than the maximum acceptable daily intake of 0.005 mg/kg of body weight set by the FAO/WHO Expert Committee on Food Additives. Also cadmium, which can produce hypertension in higher animals, does not appear to be present at dangerous levels in foods. Arsenic consumption by man is considered to be well below 0.5 mg/kg of body weight, the maximum acceptable load as set by FAO/WHO.

Contamination of seafood by mercury is widespread and the chlorine-alkali-paper industry appears to be the major source of industrial contamination. Seed dressings and fungicides are major agricultural sources. In fresh water fish, 90% of the mercury is the form of the extremely toxic methyl mercury but all mercury is not in this form in all tissues, particularly on other animals. The ability of crustaceans and mollusks to accumulate metals such as mercury magnifies the food safety problem in this food class. Several instances have occurred in the United States recently where mercury contamination of fresh

and salt water food items exceeded the 0.5 ppm tolerance and legal action was taken to protect the consumer. Complicating factors are that the background level of mercury in the environment and its movement and biomagnification are poorly understood. Methods of decontaminating soil, water, animal feeds, and human foods are not presently available.

Objectives:

a. To determine the levels of heavy metals (particularly mercury, cadmium, arsenic, and lead) in the environment.

b. To study the movement and biomagnification of mercury in the environment.

Research Approach:

Objective 1: Atomic absorption spectrophotometry and other appropriate techniques should be utilized to determine the quantity of the various heavy metals, particularly mercury, cadmium, arsenic, and lead, in the environment with emphasis on food items. Background levels should be established by sampling soil, water, plants, and animals from areas remote from industry and agriculture.

Objective 2: Use of radioactive mercury or carbon-labelled methyl mercury should be the best approach to follow in studying the movement and biomagnification of mercury in the environment. Initially, simple food chains could be studied in the laboratory. Field experiments involving both terrestrial and aquatic systems would logically follow.

Regional Needs and/or Application: Objective 1, the determination of the levels of heavy metals in the environment needs to be conducted in each state of the Southern Region to determine if any such food safety problem exists. Only then can a reasonable assessment of regional needs be made.

6. Title: Effect of herbicide applications on nitrogen levels of food crops.
SMYs 4.0 Priority 6

Situation: Certain herbicides are known to affect nitrogen levels in plants. Of importance to food safety is the possibility of increased nitrate levels on leafy vegetables and increased alkaloidal content in plants such as the potato. A herbicide may affect a crop as drift, as residue from a previous crop, or as a direct application to the particular crop.

Objective: To determine if herbicides cause unsafe levels of nitrate and/or alkaloid in food crops.

Research Approach:

a. Use pot tests for screening effect of herbicides on nitrate levels in mustard, turnip greens, and collards. Herbicides to be added at rates which might be expected to occur in practice. Nitrate fertilization to be heavy to favor any trend for increased uptake. Positive reactions are then to be studied in the field. Effect of climate is to be observed.

b. Small plot tests with varieties of potatoes known to contain the higher amounts of solanine and various herbicides likely to be present in soils on which potatoes are grown to be used. After measurement of alkaloidal levels any positive situations may be more intensively studied.

Regional Needs and/or Application: Leafy vegetables such as mustard, turnip greens, and collards are a traditional part of the diet in the Southern United States. Excessive levels of nitrate in these foods would be a cause of general concern. Infants are particularly susceptible to high rates of nitrate making it important to know whether these foods have high levels.

Potatoes, though not as important a commercial crop in the South as in the past, are a staple food. Any increase in solanine or related alkaloids could affect a large portion of the population.

7. Title: Effect of sources and rates of release of fertilizer N on the inorganic composition and alkaloidal content of crops. SMYs 30.0 Priority 7 .

Situation: With the increasing use of fertilizer N to sustain maximum yields for economic production, there is increasing concern relative to the accumulation of excessive amounts of nitrate (NO_3) and alkaloidal content in agronomic and horticultural crops, and the possible health hazards to humans (particularly infants, from methemoglobinemia) and livestock (particularly ruminants) from dietary consumption of these materials. While some plants such as spinach and beets are "naturally" high NO_3 accumulators, adverse environmental and climatic conditions including both high and low temperature extremes, drouth, inadequate light, and nutrient deficiency of inbalance, as well as excessive fertilizer N rates, can contribute to NO_3 accumulation in plant tissues. Excessive N rates may contribute to improper cation balance in the forages.

Objective: To determine the extent to which soil, crops and fertilizer management practices, including sources and rates of release of fertilizer N, can influence the inorganic and alkaloidal content of crops.

Research Approach: Both pot tests and small field plots would be useful to determine the nature of such relationships as:

a. The change in inorganic N balance of plants subject to NH_4^+ vs. NO_3 nutrition.

b. The effect of climatic and environmental factors relative to the inorganic N balance.

c. The effect of both macro-and micronutrient balances or inbalances on the inorganic N balance, and the effect of inorganic N on cation ratios.

d. The effect of sources and rates of slow release N formulations, involving coated granules, nitrification inhibitors, and fertilizers of limited water solubility, on the inorganic N balance of plants.

e. The capacity of certain species as well as varieties within species to maintain a low NO_3 level while attaining maximum yields and high product quality.

f. The effect of preplant vs. early and late sidedress applications of fertilizer N on the inorganic N balance of crop plants.

Ultimately, these investigations should involve feeding trials to determine the nutritional and physiological effects of high NO_3 feeds and forages on monogastric and ruminant animals.

Regional Needs and/or Application: Fertilizer N use efficiency in the Southeastern U.S. is probably lower than any other geographic region because the temperature and moisture conditions are conducive to rapid nitrification, leaching, and denitrification, resulting in excessive applications of fertilizer N. Increasing our limited knowledge of how current fertilizer N management practices might affect the inorganic N balance of crops in this region, should be among our highest research priorities. Leafy vegetables which can accumulate high NO_3 levels are a traditional part of the diet, and the ultimate effect on the nutritional and physiological well-being of humans and animals consuming these materials needs to be well understood.

8. Title: Rates of methemoglobin formation in relation to nitrate/nitrite levels in diet of experimental animals. SMYs 2 Priority 8 .

Situation: The reports of two infant fatalities in Europe due to ingestion of nitrate-rich, unprocessed spinach has caused considerable anxiety on the part of health agencies and processors of vegetable baby foods. The specific vegetables which may be implicated because of high nitrate content are spinach, beets, radishes, and lettuce. Medical literature on the subject of infant methemoglobinemia is scarce and contradictory but recommendations that spinach and beets be eliminated from the diets of infants under three months of age have been made.

Objective: To determine the degree of absorption of nitrate-nitrite in spinach, lettuce, beets, and radishes incorporated in the diets of suitable experimental animals and study the effects on methemoglobin formation in these species.

Research Approach: The transmission of nitrates from the soil into plants is variable. The specific plants to be studied (spinach, beets) will be analyzed for nitrate content. Variable amounts of the nitrate-containing spinach and beets will be incorporated into the diet regimens of rats, rabbits and other animals. Then blood samples will be taken and analyzed for methemoglobin and the rates of formation established. This experiment is designed to establish "safe" levels of nitrate in these vegetables.

Regional Needs and/or Application: The needs for this kind of work are universal and as such apply to the Southern Region of the United States. The Southern Region produces a large proportion of the nation's processed leafy greens.

B. Toxicants in Food and Feed

Pesticide residues inevitably occur in food and feeds as a result of chemical control of insects, diseases and weeds. The primary problem involves the more persistent chlorinated pesticides and polychlorinated biphenyls which exhibit very similar environmental effects. Since these chemicals resist rapid degradation in the food chain, more effective techniques should be devised that will hasten their biological breakdown in edible foods and feeds. Toxicologically, it would be reasonable that the same attention be given to chemical substances that occur naturally in foods as has been given to pesticide residues and food additives associated with our food supply as a result of man's efforts to improve it. Also, more precise evaluations of the subtle toxic effects of certain natural toxicants are urgently required.

9. Title: Isolation of phytoaleximes and glycoalkaloids from eggplant, potatoes, watermelons, tomatoes and other plants and study of their pharmacological and toxicological effects.
SMYs 15.0 Priority 1 .

Situation: Sporadic cases of potato poisoning have been reported in the medical literature since 1865. Germany, Eire, and Scotland have furnished most of the case histories, but some deaths have occurred in the United States. The National Academy of Science has recently set up limits of solanine glycoalkaloids permitted in potatoes, but warns that solanine may not be the sole agent responsible for the reported toxicity. Chaconines and lytines are suspect glycosides. Recent reports from the United Kingdom suggested that, on the basis of epidemiological studies, glycoalkaloids may be involved in the production of birth defects in humans (Spina bifida cystica and aencephaly). In addition to the glycoalkaloids, phytoalexins are also suspected. Because glycoalkaloids and phytoalexins have the same biogenetic precussors and occur in varying amounts controlled by specific genes, a study of the pharmacological and toxicological properties of the phytoalexins is in order.

Objective: To isolate chacanines, leptines, and other glycoalkaloids as well as associated phytoalexins for evaluation of their biological effects.

Research Approach: Use of the cardiotonic properties of the glycoalkaloids for evaluation of their toxic effects and develop appropriate bio-assays for the phyalexins.

Regional Needs and/or Application: This is a universal problem and applies to those farmers in the Southeast engaged in vegetable farming.

10. Title: Develop plant breeding programs to reduce or eliminate naturally-occurring toxicants in food and feed crops.
SMYs 10.0 Priority 2 .

Situation: Natural toxic constituents common in foods of plant origin have long been associated with a number of reoccurring human diseases and intoxications. Examples are dermatitis due to coumarin in celery and oxygen deficiency in infants due to excess Nitrates/Nitrites in processed spinach and beets.

Objective: To develop varieties of food and feed which may be safely consumed.

Research Approach: Confirm the presence, identification, and extent of occurrence of toxic factors. Survey available germ plasm to obtain source material low in a specific toxicant, and incorporate into a variety development program. Plant selection should emphasize low toxicant content (food safety) as well as traditional horticultural values.

Regional Needs and/or Application: The Southern Region produces a large percentage of the annual national food supply through the use of agronomically and horticulturally superior varieties of food and feed. Precisely because of the nationally prominent production position, Southeastern food and feed producers must be supplied with varieties free of naturally occurring toxicants.

C. Aquatic Foods

A large percentage of fish from fresh and salt waters is subjected to serious public health problems because of improper procedures during harvest, processing, transportation, and distribution. In addition, efforts are underway in Southern states to raise both fresh and marine species in confinement. There is little information available on the safety of these foods.

11. Title: Health-related aspects of chemical, microbial and other biological factors in commercial seafoods. SMYs 50.0 Priority 1 .

Situation: Seafood harvested from the warm water environment of the Gulf of Mexico and the South Atlantic is exposed to high populations of microorganisms associated with seafood and fishery products as well as microorganisms derived from man, specifically the coliform group. This is in contrast to the situation in the cold waters of the North Atlantic. The Gulf of Mexico and the South Atlantic also serve as the final regional repository of chemicals, including pesticides and toxic metals such as mercury and cadmium. Under these conditions, it is imperative that the present microbiological and chemical factors of seafood and fishery products be examined and ascertained.

The mishandling of refrigerated or frozen seafoods in wholesale and/or retail channels can result in products that are hazardous to man. This is particularly true when microbial populations increase from relatively insignificant levels to potentially dangerous levels during storage at unsafe temperatures for long periods. Hazards to many may result from consumption of products not properly heated or through cross-contamination.

Objectives:

a. To adapt the methodology essential for isolating and enumerating microbial species and chemical factors in the environment affecting seafood and fishery products which are potentially hazardous to man.

b. Simple inexpensive procedures need to be developed that will indicate if the product in individual packages and lots has undergone chemical and microbiological changes that are potentially dangerous to the consumer.

c. Indices of pollution should be accumulated to allow regionalized pooling of data and computer analysis from participating investigators.

Research Approach: Specific methods should be developed for the isolation and enumeration of microbial species that can be potentially dangerous to man. In addition to simplicity and rapidity in methodology, special attention should be devoted to plating conditions (composition of plating medium, time and temperature of plate incubation), which will take into consideration the environment of the fish species (salt in media for example), the effect of the sample on the selectivity of

the medium, and the temperature and time of incubation conducive for the recovery of the microbial species. A similar approach should be taken in the evaluation of chemical methods.

Regional Needs and/or Application: Many of the Southern states have a large economic interest in seafood and fishery harvested commercially from the Gulf of Mexico and the South Atlantic. Preservation of safety of seafoods is important in the Southern coastal states of Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina and Virginia where seafoods are of economic significance. The proposed research could be conducted cooperatively through existing staff and facilities at land grant institutions and marine stations of the several states.

12. Title: Health-related aspects of developing commercially valuable products from non-utilized aquatic products. SMYs 15.0 Priority 2 .

Situation: A large quantity of aquatic products or by-products is available or potentially available which has no present economic value. Sometimes proper disposal of these products is an economic burden to the industry. In many cases the proper application of technology would result in an economical and useful product. Examples are marine trash fish or fish grown in cultures incidental to the main crop, waste from fish processing plants, and utilization of fish grown for purposes other than food such as the white amur (Ctenopharyngodon idella), which is an effective biological control for aquatic plants.

Potential uses of these products are human foods, pet foods, and animal or fish feeds. Specific areas that show favorable potential in the Southern region are the utilization of catfish processing plant wastes and marine trash fish in diets for fish grown in confinement. The addition of fish meal or raw fish to the diets of cultured fish has been demonstrated to be extremely beneficial. Also, the addition of aquatic by-products to fish diets greatly improves palatability. Studies of catfish processing waste have demonstrated that this product has excellent food value for swine and catfish. Whatever the application, the human health aspects related to these currently non-utilized products have not been pursued to a significant degree.

Potential hazard of using fish by-products or trash fish in diets of mammals or fish used for human food is contamination with pathogenic microorganisms. Also, residues of harmful elements or compounds may be concentrated and stored in fish tissues, particularly in visceral organs, making the fish or their by-products significant sources of the chemical residues.

Objective: To analyze fish processing wastes or trash fish that may be used in fish or animal diets for microorganisms and chemical residues hazardous to human health.

Research Approach: Aquatic wastes shall be analyzed for health-related microorganisms at their sources and in various forms, in which they may be used in diets of food fish or mammals. The effects of various methods of processing, storing, and dispensing the fish products upon survival of the various microorganisms need to be studied. Procedures for minimizing the probability of these aquatic products being sources of biological contamination of food need to be developed.

Fish tissues, particularly adipose and liver tissue, should be analyzed for selected chemical residues to determine whether these fish products are a source of residues. Fish should be exposed to concentrations of various materials, such as heavy metals, pesticides, or polychlorinated biphenyls, and subsequently subjected to various methods of processing the fish or by-products. The effects of environment and processing methods on the level of chemical residues in these fish products should be evaluated. Surveys will be made for selected chemical residues in tissues of fish from natural sources or commercial cultures to evaluate the hazard of using fish or by-products as animal and fish feeds.

Regional Needs and/or Application: Commercial uses for waste from aquatic processing plants have not been developed. Approximately 40 million pounds of catfish, grown essentially in the Southern and Eastern Regions, were processed for human food in 1971, but only 55% to 60% of the product had commercial value. Several methods of processing this waste for fish or animal feeds are being investigated at research stations in the Southern Region; however, no work is being conducted on the human health aspects of such applications. Any practical method for utilizing catfish waste must not be a public health hazard. Trash fish from commercial fishing in coastal areas of Southern U. S. are potentially useful feeds for fish cultured along the coasts, such as shrimp, pompano and other species. The feasibility for utilizing this product for fish feed will also depend upon public health aspects as well as economics.

13. Title: Public health hazards of aquatic species grown in confinement. SMYs 25.0 Priority 3 .

Situation: Catfish and crawfish are presently the most abundantly cultured food fish in the Southern Region as well as the entire United States. Commercial culture of catfish for food is an established and rapidly growing industry in the South. In 1971, the National Marine Fisheries Service reported that 40 million pounds of cultured catfish were consumed as human food. The industry has essentially developed during the last five years. Culture of other freshwater and saltwater species in confinement is increasing in scope in the South. Confined species may become contaminated much more quickly under improper conditions.

Objective: To monitor the microbial safety and quality of commercially cultured species during production, processing and handling.

Research Approach: To evaluate the major microbiological and chemical factors indigenous to catfish and crawfish culture ponds and processing plants. The sanitation status of processing and handling practices currently being used in the catfish industry should be investigated. Methods for microbiological analysis of catfish and crawfish products need to be applied. Microbiological evaluation appears to fall into two areas:

a. A microbiological survey of commercially cultured food catfish and crawfish at various points between the production source and the consumer: analysis for health-related bacteria to include such microorganisms as Salmonella sp., fecal coliforms, Vibrio sp., clostridia species, coagulase-positive staphylococci and other organisms that may be of interest.

b. Methodology needs to be applied to the bacterial analysis of processed catfish and crawfish and processing and handling facilities. Areas for development include statistical procedures for sampling, sampling sites and procedures, storage and transport of samples, laboratory procedures and interpretation of data.

Regional Needs and/or Application: Research on the microbiological status of catfish and crawfish culture and processing is of great economic importance to several Southern states. The land-grant institutions in these states have initiated research programs in the area. An expansion of these programs is urgently needed. Data will be useful for establishing processing guidelines and for product evaluation by public health agencies.

II. Food Processing and Manufacturing

For purposes of this report food processing and manufacturing encompasses the various food preservation unit operations such as cleaning, preparing, canning, pasteurizing, freezing, concentration, and dehydration designed to prevent growth of spoilage and poisoning microbes while preserving nutritional value and converting the food into desirable or convenient form. This area also includes new food forms which may evolve from formulations using both traditional and newly developed food ingredients. Research in this problem area must take into account all operations or treatments which may affect the safety or wholesomeness of the final process or manufactured product as consumed.

1. Title: Methods to minimize the dissemination of salmonellae, and other harmful microorganisms during processing of poultry and red meat products.
SMYs 35.0 Priority 1.

Situation: Poultry, swine and cattle presented for slaughter may harbor salmonellae and other harmful microorganisms in their intestinal tracts and/or on their external surfaces; e.g., on feet, feathers, hair, hides, skin, etc. Many of these organisms are not eliminated during normal commercial processing and often contaminate processing waters, equipment, materials, personnel and the general environment of the plant. This often results not only in increased contamination of products but also of byproducts destined for animal feeds, thus perpetuating the cycle of contamination. The possibility also exists that air from red meat and poultry processing plants may serve as a vehicle of contamination of foods in nearby plants.

Objective: To devise effective means of controlling the dissemination of salmonellae and other harmful microorganisms during processing of poultry and red meats.

Research Approach:

a. Develop new methods and equipment for slaughtering, defeathering, dehairing, evisceration, and chilling that will minimize cross contamination among carcasses and inhibit the growth of harmful microorganisms and/or formation of microbial toxins.

b. Evaluate the extent to which salmonellae and other harmful bacteria contaminate the air in processing plants and the relation, if any, to (a) product safety and (b) contamination of air adjacent to slaughter and processing plants. Include studies on survival and, if necessary, devise feasible methods for destroying airborne microorganisms.

c. Develop effective physical and chemical treatments for "pasteurizing" raw meat and poultry products and combine with suitable packaging techniques to prevent recontamination during marketing.

d. Develop improved quality assurance systems and techniques for monitoring bacteriological status of processes, equipment, materials, ingredients, environment and product in red meat and poultry processing plants.

e. Devise improved methods and equipment for collecting, transporting and handling of offal and other byproducts to be rendered to minimize transfer of contaminants to finished food or feed products and prevent their dissemination in the environment.

Regional Needs and/or Application: Millions of broilers are processed annually in the Southeast and the volume of red meats processed here is likely to increase sharply soon. In the very near future more rigid microbial standards for fresh meat and poultry and other food processed in this region are likely to be proposed and strictly enforced by regulatory and inspection agencies. The research outlined above will help insure that foods manufactured in this region will be able to meet those new standards and, therefore, remain salable.

2. Title: Systems to minimize microbial or chemical contaminants while optimizing reuse and recycling of processing water in food processing plants.
SMYs 110.0 Priority 2 .

Situation: The water discharged from food processing plants must be reduced in order to have adequate pollution control and conserve water. Recycling of processing water can cause concentration of undesirable chemical, microbiological and non-food components. Research is needed to assure optimum recycling, with minimum water use while maintaining quality and wholesomeness of food products.

Objectives: Determine sequence and treatment for safe reuse and recycling of processing plant water. Develop technology whereby water to clean raw products and use in other processing operations can be treated to remove foreign material, remove or deactivate chemicals and eliminate microorganisms so the water can be safely reused or recycled.

Research Approach:

a. Determine most effective sequence of processing operations to provide reuse of water and maintain product quality.

b. Develop and evaluate equipment for removing foreign materials and deactivating chemicals in water for reuse in food processing plants.

c. Determine treatments necessary to insure reused or recycled water is free of pathogenic and spoilage microorganisms.

d. Assess long-term effects of recycling water within specific types of food processing plants and develop plans for optimum replenishment of water.

e. Study specific operations such as dry caustic or freeze peeling or cleaning using low water and non-water systems for their effects on product safety and wholesomeness.

Regional Needs and/or Application: State and Federal laws require food processing plants to reduce the amount of their discharge water. Many food processing plants will be forced to stop processing unless means are found for satisfactory reuse or recycling of water within their plant. There are special needs in the Southern Region due to shallow water tables, and danger of salt water encroachment when water tables are partially depleted. The increasing influx of people into the Southern Region will also increase needs for non-production uses of water, thus demanding more efficient water use in processing plants. Increasing needs for minimizing water usage will increase potential problems in food safety related to water reuse.

3. Title: Chemical and microbiological problems associated with the use of nitrate and nitrite.
SMYs 15.0 Priority 3 .

Situation: Nitrate and nitrite salts have been used for centuries in curing and preserving meat and poultry products. Nitrite conbines with myoglobin to form nitrosomyochromagen - the heat stable, pink pigment of cured meats. More important is their bacteriostatic effect against Clostridium botulinum.

When present in canned and vacuum-packaged food nitrites cause a reduction in growth potential for C. botulinum. Thus, the time-temperature relationship of the processing cycle may be lowered resulting in a higher quality product with better consumer acceptance.

During normal processing and storage, amines are formed from protein degradation. Certain amines may react with nitrite to form carcinogenic nitrosamines. The possibility appears to exist for the formation of these carcinogenic compounds in foods containing nitrite and their ingestion by man.

Objective: Evaluate the role of both nitrate and nitrite in insuring the safety of cured foods and what effect various handling conditions have on the potential microbial and chemical health hazards of these foods to the consumer.

Research Approach:

a. Determination of the natural levels of nitrate, nitrite and nitrosamines in edible foods and factors that affect these levels.

b. Determination of the effect of various levels of nitrate and/or nitrite on growth and/or toxin production of pathogens in cured foods subjected to normal and abnormal handling conditions.

c. Determine what levels of nitrosamine compounds are formed in cured foods during processing, storage, and preparation prior to consumption and, if so, under what conditions and nitrate and/or nitrite level.

d. Determine if feeding cured foods to animals results in nitrosamine compounds in the digestive tract, blood, excreted material or tissue. When present, what levels of nitrate and/or nitrite are necessary in the product and how should it be handled prior to being fed to the animals?

e. Determine if cured food products can be manufactured with none or reduced levels of nitrate and nitrite in conjunction with other food additives to yield safe products with good consumer acceptance.

Regional Needs and/or Application:

a. The Southern Region produces many foods which contain various levels of nitrate and nitrite. Some parts of this region could suffer large economic losses if the use of nitrate and/or nitrite prohibited the manufacture and sale of these products.

b. To fully understand the problem, information is needed to insure that nitrate and/or nitrite are necessary in these products. If found to be necessary, then the levels used must offer adequate protection to the consumer against all microbial and chemical health hazards which could result from misuse of these products prior to consumption.

4. Title: Improvement in pre-processing treatments of plant and animal raw food materials.
SMYs 80.0 Priority 4 .

Situation: Raw horticultural and agronomic materials are transported by truck, railroad and other means to the processing plant. The methods of handling plant materials prior to and after harvest are not often controlled from the standpoint of microorganisms, viruses, insects, chemical residues and other foreign material. The methods of preparation for processing are important to the quality, improvement and safety of foods. Similarly, milk, livestock, poultry and eggs are gathered and transported to processing plants under conditions which often result in increased levels of infected or contaminated products. Many agricultural commodities, due to increased sizes of crops and increasing labor costs, are being mechanically harvested. This practice will undoubtedly increase in the near future. Mechanical harvesting practices increase the probabilities of contamination with damaged raw food materials, and inclusion of dirt, trash, and other non-food components. All of these conditions increase the need for research in pre-processing treatments.

Objective: To eliminate or reduce the incidence of contaminants and pollutants on raw food materials before processing and minimize incidence of infected (contaminated) animals before slaughter, in order to insure satisfactory preservation, product quality and wholesomeness.

Research Approach:

a. Develop model systems for cleaning of raw products before or in early stages of processing: Review design, operation of equipment, microbiological, pesticide, and foreign material loads, and chemical treatments of raw food materials to reduce microbial contamination in processed products.

b. Develop new methods and approaches to peeling and grading of raw materials:

   (1) Examine methods to retard enzyme systems during handling and peeling, as well as after peeling.

   (2) Assess beneficial and detrimental effects of pre-peeling and pre-grading.

   (3) Develop high-speed mechanical grading systems to handle high volumes of raw food materials resulting from mechanical harvesting practices.

c. Examine new blanching techniques for raw food materials in preparation for processing. Study efficiency of water usage, effects on quality and efficiency of other operations, and on microbial and chemical aspects of the products.

d. Devise improved methods of collecting and transporting animal products to minimize contaminants prior to processing:

   (1) Evaluate existing handling practices for milk and eggs and develop tests to assess sanitary quality immediately prior to pickup.

   (2) Devise improved methods for on-farm collection, cleaning, and holding of eggs to minimize contamination.

e. Develop improved methods for gathering and transporting livestock and poultry to processing plants to minimize contamination:

   (1) Devise economical methods to clean and sanitize trucks, coops and other equipment used to transport animals or poultry to processing plants.

   (2) Design poultry and livestock transporting methods to minimize stress, reduce cross infection (particularly by salmonellae), and dissemination of contaminants (feathers, dust, and fecal material) to the environment.

Regional Needs and/or Application: Because of the disappearance of small processing plants, consolidation of larger ones, the accumulation of raw materials from many locations and the adoption of mechanical harvesting systems for many fruit and vegetable commodities in the South, the contamination of raw materials by air, water, and solid transfer has become a prevalent problem. This will become increasingly important over the next few years. Raw materials travel longer distances across state lines in many Southern States and some States are quarantined against certain contaminants. The variability between states creates some problems peculiar to the Southern Region. Some Southern commodities where there are special needs for these studies include poultry, peaches, leafy vegetables, beans, citrus, and nut and root crops. Some of these studies can be developed from current practices in other areas.

5. Title: Control of Clostridium botulinum, Vibrio parahaemolyticus and other pathogens in pasteurized, smoked and preserved aquatic foods.
SMYs 45.0 Priority 5 .

Situation: Pasteurization of crabmeat and smoking of mullet have been effective in prolonging the shelf life and improving the consumer acceptance of these aquatic food products. However, neither process provides sterilization of the product and may in fact promote the development of deadly Clostridium botulinum and other heat-resistant pathogens as a result of milder heat treatments that reduce the level of competitive organisms.

Objective: To minimize the hazards of pasteurization, smoking and other methods of preservation of aquatic food products and at the same time maintain their consumer acceptance qualities and nutritive value.

Research Approach:

a. Systematic monitoring of the incidence of pathogenic organisms in the production, handling and processing operations of aquatic foods.

b. Investigations of practices to reduce the hazards of pathogenic organisms without marked changes in desired quality of products, e.g. improved heat transfer, development of better sanitation principles, etc.

c. To conduct storage investigation of the shelf life of preserved aquatic products in relation to their food safety and quality acceptance.

Regional Needs and/or Application: The Southeastern States have experienced a rapid expansion in the production and processing of aquatic food products. The warm seasonal temperatures are particularly conducive to the development of microorganisms including those with pathogenic activity. In view of the potential for further development of the fish processing industry because of favorable climate and rapidly increasing human population in the region, it is highly important to investigate the incidence and control of pathogens in pasteurized crabmeat, smoked mullet and other significant aquatic food items that are of regional importance in the South.

6. Title: Identification and reduction of natural toxicants and of environmental and microbiological contamination of plant products. SMYs 30.0 Priority 6 .

Situation: Naturally occurring toxicants are present in plant products, such as, cyanogenetic glycosides in almonds and stone fruit kernels; estrogenic activity in prunes, plums, apples and cherries; cholinesterase inhibitors in Stayman apples; pressor amines in bananas, pineapples, plantains and tomatoes; goitrogens in strawberries, peaches, pears, and peanuts; and anthraquinone glycosides in rhubarb. New varieties of these commodities may pose additional problems in our food supply. Conversely, processing methods may be developed to remove or destroy these substances in foods.

Contamination of plant products by improper use of agricultural chemicals as well as by introduction of environmental contaminants such as sulfur oxides, hydrocarbons, and oxides of nitrogen is of increasing concern. The effect upon food quality of many environmental contaminants is not known and, therefore, requires intensive study. There is also the danger that food spoilage organisms may contaminate composite foods when unheated plant products are combined with ingredients which, although microbiologically safe themselves, provide favorable growth conditions.

Objectives: Evaluate the roles natural toxicants and environmental and microbial contamination play in affecting the safety of plant products. Determine proper processing conditions to minimize the deleterious effects of these hazards.

Research Approach:

a. Evaluate the new plant products for the presence of natural toxicants.

b. Develop or investigate the effects of processing methods upon any possible natural toxicants which may be present.

c. Determine the possible effects of environmental contaminants such as, pesticides, sulfur oxides, hydrocarbons, carbon monoxide, photochemical oxidants and nitrogen oxides in determining the final quality of plant products.

d. Determine the incidence of coliform and fecal coliform bacteria in mechanically shelled nutmeats. These nutmeats are often used in confections and ice cream with no further heating, so additional or improved control measures to minimize microbial contamination should be developed.

e. Determine proper methods of harvesting, processing and storage that will minimize recontamination of plant products with pathogenic mycotoxins.

Regional Needs and/or Application: Hazards resulting from natural toxicants and environmental and microbiological contamination of plant products are both regional and national in scope. However, due to its large production of plant products, the Southern Region has a legitimate interest in minimizing any danger arising from these problems.

7. Title: Community canning centers and home preservation and storage of food.
SMYs 10.0 Priority 7 .

Situation: There are many publications from the State Agricultural Extension Services, the utility companies, suppliers of seed and home equipment, as well as other sources, giving recommended procedures for the preservation and storage of food in the home. A review of some of these publications shows that certain procedures are recommended which have not been checked for safety. For example, in one publication the time and temperature for canning certain low acid vegetables in #3 size cans is based on the time and temperature established for #2½ size cans. In the larger size cans the time and temperature could likely be insufficient for the destruction of Clostridium botulinum spores. Other recommendations in some of the publications are probably giving inadequate guidance with respect to the handling and storage of foods to protect consumers against food borne illnesses.

Objective: To develop safe and improved methods and procedures for the preservation and storage of foods at community canning centers and in the home.

Research Approach:

a. Put up test packs using those procedures that are in doubt and examine packs for the factor or factors which could be safety problems.

b. Identify those recommendations from the Southern Region where there can be any possible basis for raising questions about product safety. The safety could be related to an inadequate processing method, the use or quantity of additive not acceptable, existing dangers with respect to the food formulation, the excessive destruction or loss of nutrients and unacceptable storage conditions.

c. Prepare standardized recommendations for the safe preservation and storage of foods.

Regional Needs and/or Application: Every State Extension Service in the South publishes circulars and bulletins on home preservation. There is still a reasonable amount of home preservation within the region and probably there is some increase with the emphasis today on the use of natural foods. Some recommendations with respect to home preservation do not appear to have an adequate factor for safety.

8. Title: Assure safety of animal feeds and food comprised of by-products and waste from food processing.
SMYs 100.0 Priority 8 .

Situation: Byproducts such as whey, marine, offal, blood, feathers, fruit and vegetable wastes are being used in foods and animal feeds. Because of the increased emphasis on health hazards, the processing and handling of these byproducts will need to be carried out under rigid surveillance and quality control. The incidence of build-up or occurrence of pathogenic bacteria, viruses, and chemical residues are important in assessing wholesomeness of products while minimizing pollution problems.

Objective: To assure the safety and wholesomeness of byproducts from wastes from food processes while using the waste materials as completely as possible and avoiding dangerous accumulations of undesirable or unwholesome components in such byproducts.

Research Approach:

a. Design and evaluate equipment needs for safe and sanitary collection, handling and processing of waste materials. Determine effects of primary process on bacterial load and undesirable chemical residues in byproducts.

b. Determine the suitability of wastes and byproducts for recycling as animal feed or human food through chemical analyses of wastes and evaluation of chemical treatments of the raw product or process which may affect wholesomeness of such byproducts. These include use of hormones or antibiotics in animals, abscission chemicals and pesticides in fruits and vegetables.

c. Develop long-range systems of complete reuse of waste and by-product materials. Assure safety of byproducts through evaluation of long-range microbial, virus, pesticide, and chemical accumulations. Study effects on nutritional value of byproducts, as well as quality assurance upon long-range usage.

Regional Needs and/or Application: The Southern Region has developed major processing areas for poultry, marine products, processed fruits and vegetables, preprocessed beef and dairy products. Much of the waste or byproducts from these processes have been utilized haphazardly for animal feed and other byproducts without regard to cross-contamination possibilities between waste disposal areas and food manufacturing areas. Little study has been carried out on build-up of hazardous pesticides or increases in viral and bacterial contamination from these practices. The Southern Region needs to develop a controllable and beneficial long-range program for reuse of waste and byproducts. Results of such studies would be immediately applicable on vegetable, fruit, animal and marine wastes.

9. Title: Thermal requirements for safe processing of canned Southern foods.
SMYs 20.0 Priority 9 .

Situation: Under present commercial practice, some difficulty arises in obtaining proper filled and drained weight of Southern foods, such as greens, peanuts, okra, eggplant, dried legumes and other products. Part of these items are often packed with added fat and other seasonings which may be of questionable microbiological quality. Entrapment of bacterial spores in low-moisture fat, viscous brines or sauces, and over-filled cans poses problems in bacterial destruction. Product stratification during filling due to specific gravity creates abnormal conditions of heat transfer. Certain new products to the region such as eggplant and mushrooms may require additional research and/or application.

Objective: Determine time-temperature relationships of blanching and thermal processing to attain sterility of Southern canned foods.

Research Approach:

a. Evaluate present time-temperature relationships of blanching to attain proper fill and drained weight and establish guidelines to follow.

b. Determine relationships of blanched product to brine ratios, fill and maturity of crop to thermal processing characteristics for sterility of product.

c. Determine the influence of fats, sauces, brines, etc., on spoilage rates and quality.

Regional Needs and/or Application: Many products such as "Southern greens", "Southern peas", eggplant, peanuts, okra, etc., are unique to the South. Even though safe thermal processes have been determined for some of these products, many variations of these items are marketed commercially, sometimes only in specific areas. With the increasing cost of living, the consumption of low cost foods is increasing rapidly, and many of these are in this category. The production practices and the size of smaller canneries in the South pose limitations on their ability to develop the necessary data and technology for safe processing of many of these products. Therefore, this research should provide additional information and guidelines that are not presently available for many of these product variations.

10. Title: Injury phenomena of microorganisms caused by food processing methods.
SMYs 25.0 Priority 10 .

Situation: Rapid changes in food processing technology have placed demands for longer shelf life for processed foods and dairy products stored at refrigerator temperature. Processing methods that do not give commercial sterility do not necessarily destroy all potential food poisoning or food spoilage bacteria in these products. Current evidence indicates that a certain fraction of the microbial cell population in these foods survive because they are apparently only sublethally injured rather than killed by the processing methods used. Hence, that fraction of cells that are able to repair this sublethal damage will be able to reproduce and pose problems of food safety and food spoilage.

Objective: Determine to what extent microbes are injured by food processing methods and what conditions are necessary for repair and growth of these stressed cells.

Research Approach:

a. Develop methods for identifying and characterizing injury in populations of microbial cells.

b. Determine what fraction of microbial populations in raw food products is destroyed vs. the fraction that is merely injured by the food processing stresses used: (e.g., heat, freezing, curing, etc.)

c. Determine, following stress, when and under what conditions repair of injured cells occurs and the mechanisms involved.

d. Determine conditions necessary for growth of repaired cells during handling and storage of processed foods.

Regional Needs and/or Application: The safety and shelf life of processed foods depend upon destruction of all pathogens and the destruction or growth inhibition of spoilage microbes. Foods processed by methods that merely sublethally injure some rather than destroy all microbes present may subsequently be handled or stored under conditions which permit repair and growth of injured cells. The economic losses to manufacturers due to spoilage and the potential health hazards to the consumers of the Southeast can be minimized by information gained in this study.

11. Title: Pathogen survival in fermented versus directly acidified foods of animal origin and safety of such foods when pickled. SMYs 40.0 Priority 11 .

Situation:

a. Direct acidification has been proposed to increase production rates in the manufacture of certain cheese and sausage products and this method is already to some extent used commercially. The survival of bacterial pathogens in foods produced by this method has been scarcely investigated. In contrast, the starter cultures used when such foods are naturally fermented ("bio-processed") have been shown to aid in the destruction of pathogens like salmonellae and staphylococci.

b. Commercial preparation of pickled eggs and meat products involves several hand operations, especially in smaller plants. There is obviously an opportunity during processing for the transfer of pathogens from the workers and environment to those foods which can support the growth of pathogens. Whether the different pickling acidities used in commercial egg and meat pickling operations today are adequate to destroy bacterial pathogens has not been thoroughly investigated.

Objectives:

a. To compare the survival of pathogens in cheese and sausage products manufactured with direct acidification and with starter cultures.

b. Determine the processing measures needed to produce pickled eggs and meat products that are microbiologically safe.

Research Approach:

Situation a:

a. Determine if bacterial pathogens survive (are they killed or only injured?) in current commercially used direct acidification processes.

b. Evaluate other food-approved acids and chemicals for their ability to destroy pathogens during cheese and summer sausage manufacture.

c. Determine how food components and processing schedules can be adjusted to enhance the lethal effects of acid on pathogens in these foods.

d. Determine whether cheese and other dairy products made by direct acidification are as digestible and nutritious as those made by conventional bio-processing.

Situation b:

a. Determine if bacterial pathogens introducable during human handling can survive in the currently used commercial pickling solutions.

b. Determine what combinations of acid concentrations and pH values are adequate to destroy or prevent the growth of pathogens.

c. Devise machines that will peel hard-cooked eggs thereby obviating the need for hand peeling which would reduce contamination from human handling.

d. Determine the survival in pickling solutions of the microbial load introduced from the spices added.

Regional Needs and/or Application:

Situation a: The value of dairy products marketed in this region comprises an important percentage of total food sales in this area. Economic pressures often dictate that new technologies, such as direct acidification, be adopted before their microbiological safety has been fully evaluated. Research to that end would provide food processors with the information they need in deciding whether to use direct acidification or conventional biological processes in the manufacture of these foods.

Situation b: Consumption of pickled eggs is increasing in the Southern Region and this product offers an economically attractive way to utilize under-size eggs. These pickling operations currently are small, kitchen-type operations with each processor following his own recipe. The consequent variation in acid strengths could mean that not all of the currently used egg pickling procedures are adequate to render this product microbiologically safe. Pickling solutions used for meat products should also be evaluated for their adequacy.

12. Title: Potential health hazards from the use of natural and synthetic food additives.
SMYs 20.0 Priority 12 .

Situation: Most of the food additives (emulsifiers, acidulants, enhancers, leavening agents, preservatives, antioxidants, synthetic sweetners, etc.) are used to enhance, modify or improve the quality attributes of convenience foods and beverages. There has been a continual development and an increase in consumption of new, fabricated, engineered or analog foods and beverages, such as meat substitutes, beverages and dairy substitutes that have increased the use of additives. Many sets of conditions are imposed upon convenience foods during manufacturing, processing, packaging, storing, and distributing that can affect the safety of food additives. Toxic substances may be formed, especially if food additives are misused.

Objective: To develop methods and test toxicological and other properties, evaluate safety and wholesomeness, and assess the effectiveness and necessity of using these natural and synthetic food additives.

Research Approach: Evaluate and/or develop methods of determining safe levels of use and the fate, absorption, distribution and excretion of these additives or breakdown products in animals and man. Toxicity studies should be carried out to determine safe levels of intake as related to age groups, ethnic groups, long range risks, etc. Also, to compare the effectiveness of safe rates of the additives against control samples to determine necessity of their use in certain foods.

Regional Needs and/or Application: The Southern Region produces and processes significant quantities of food consumed by the American consumer. There is a rapid migration of a large percentage of the population to the South as well as a rapid increase in number of large processing plants. Because of the higher yearly mean temperatures and uniqueness of some of the foods produced and consumed in the Southern Region, the dangers to health are sometimes greater. Areas of concern are phosphates, use of smoke, EDTA, SO_2, anti-microbial agents, acidulants, desiccants, etc., and feed additives such as DES, antibiotics, arsenicals and other growth promotants in animals. This research will contribute significantly to the scientific and technological information needed by the agricultural and food industries of the South.

13. Title: Formation of toxic constituents during processing and storage of foods.
SMYs 30.0 Priority 13 .

Situation: Pasteurization, high temperature thermal processing and dehydration are commonly used effective measures to preserve the shelf life of foods. Many foods are cooked by deep-fat frying. However, certain natural constituents, such as fats, may be changed or modified during processing and thus may yield hazardous products. Thermally induced reactions occurring in lipids under both oxidative and non-oxidative conditions are of interest. Toxic materials produced by lipid oxidation can also occur in foods stored in contact with oxygen for long periods of time. This problem is particularly serious for dehydrated food products in which the lipids are spread over a large surface area. Solvent extraction of oil-bearing seeds provides an example of a problem that may arise when there is an interaction between the substance being processed and the material used in processing that may produce a highly toxic substance. Residuals from fumigation, flour bleaching and maturing agents, and formation of antimetabolites have all been recorded as problems arising during food processing. Problems have also been associated with browning reactions and smoking of foods.

Objectives:

a. To process and store certain classes of foods under specified conditions using selected processes and determine the presence or absence of toxic constituent(s).

b. To establish the identity and relative toxicity and other effects of suspect, induced toxicant(s).

c. To relate formation of any toxic constituent(s) to commercial processing and storage conditions.

Research Approach: Selected foods and processes (thermal processing, dehydration, smoking, etc.) will be chosen and standard conditions of treatment established. Treated foods will be evaluated both before and during storage for the presence of toxicant(s). Toxicant(s) will be isolated and their toxicity established using suitable laboratory animals. Conditions and mechanisms for formation of the toxic constituent(s) will be studied and the relationship of these conditions to processing and storage operations determined.

Regional Needs and/or Application: Rapid advances in food science and technology have resulted in the introduction of many new food products and processes. Marked alterations in safety and wholesomeness may occur. A detailed study of the effects of these processes and process modifications will benefit the industry of the Region and the consumer.

14. Title: Potential microbial and toxic hazards of fabricated foods.
SMYs 20.0 Priority 14 .

Situation: Predictions have been made that by 1985 two-thirds of the foods consumed by Americans will be in forms and derived from sources not familiar to the public today. A familiar example, textured vegetable protein is used both as a component of completely engineered foods and as an extender which is mixed with meat in hamburger-style dishes. It has been suggested that by 1980 this type product will replace 10-20% of the meat items in our diet. It is possible that the vegetable protein could act as a carrier for food spoilage microorganisms. Thus the danger exists that with careless sanitary procedures microbiological contamination or cross contamination could occur. Another type of engineered food is the cookie-type product designed to replace one or more conventional meals each day. A portion of the population due to disease or metabolic dysfunction may find these foods hazardous because of the presence of deleterious ingredients. The level of sodium chloride found in some of the cookie products and textured vegetable proteins is not safe for individuals suffering from hypertension. Some of the imitation milk products contain lactose which is intolerable to many people and yet these products are described as milk substitutes.

Objective: To evalute hazards arising from the production or use of engineered foods by (1) investigation of possible microbial contamination of those products which must be cooked and those which are consumed without further preparation. (2) Determination of the chemical composition of engineered foods with particular emphasis on the types and amounts of minor ingredients.

Research Approach:

a. Measure microbial contamination of vegetable protein as supplied by manufacturers and of the finished engineered food before cooking to include both freshly prepared and stored products.

b. If significant contamination exists, devise procedures to minimize or eliminate it.

c. Obtain samples of many types of engineered foods and determine the identity and levels of such ingredients as salts, minerals, simple carbohydrates, etc.

d. Conduct animal feeding studies to determine whether hazards exist from long-term usage.

e. In cooperation with health authorities, determine if hazards do exist because of the ingredient(s) either to the general population or to individuals with specific disorders.

f. Where hazards do exist alert the proper authority to the danger so that corrective action may be taken.

Regional Needs and/or Applications: The engineered foods are being used to an increasing extent in the South as well as other regions. Some of these are being used in the school lunch programs and probably will be used in feeding programs with the aged. Moreover, large numbers of the population are being exposed to these foods via the so-called "instant-breakfast" or through diet foods.

15. Title: Microbiological contamination from spices, herbs and other minor ingredients in convenience foods.
SMYs 20.0 Priority 15 .

Situation: Recent microbiological surveys reveal that several spices, pepper in particular, contain high levels of bacteria and fungi. Spices, herbs and other flavoring materials are used in the formulation of many convenience foods some of which receive little heating at home before they are consumed. Such products could, therefore, become microbiologically unsafe prior to consumption.

Objective: To reduce the microbial load on spices, herbs, and other minor ingredients added to convenience foods which receive little subsequent heating so that the microbiological safety of such is not compromised.

Research Approach:

a. Devise other effective methods to reduce the microbial count in spices and herbs.

b. Determine whether food processing methods presently used in manufacturing convenience foods adequately reduce the microbial load introduced by minor ingredients during formulation.

c. Determine whether the home preparation and storage methods suggested by convenience food manufacturers are adequate to prevent the growth of any potential pathogens that may have survived manufacturing and home cooking procedures.

Regional Needs and/or Application: The South is experiencing a rapid growth in population and this trend is projected to continue for some time. Because of its central location and the rapid availability of raw materials, this area is well suited for the production of convenience foods. Many of these food formulations are based on southern foods that are highly seasoned due to local and ethnic influence. Such foods comprise an important and growing percentage of grocery sales nationwide. To support the development and growth of companies manufacturing these foods in this region, the research outlined above will be needed to insure that these food items remain microbiologically safe during distribution and home preparation.

16. Title: The influence of packaging materials on the composition and safety of foods.
SMYs 10.0 Priority 16 .

Situation: Food packaging materials are developed primarily for the protection of quality and nutritive value of the products, for desired functional properties such as rigidity or flexibility, and for aesthetic attractiveness in merchandising. Polychlorinated biphenyls (PCBs) were suspected of becoming incorporated in food packing materials, particularly through recycled paper products. The harmful properties of these and other substances are not known but they have characteristics that resemble persistent insecticides. There is a continuing hazard that certain packaging ingredients including coatings and labelling dye constituents may migrate from the package to the product and result in significant toxic effects. There is also a potential hazard to packaged foods from insect infestation and from lack of integrity of the package when subjected to warm temperature and humidity.

Objective: To reduce or eliminate the hazards of toxic or potentially toxic materials being incorporated into food packaging materials and subsequently migrating to the food products.

Research Approach:

a. Assessment of primary packaging materials to determine ingredients capable of migrating to food products and characterization of migratory ingredients for toxic potential when combined with edible foods.

b. Development of alternative packaging ingredients that are biologically inert yet have desirable functional properties.

c. Determination of resistance of packaging materials to insect infestation and to maintenance of integrity under warm temperature and humidity conditions.

Regional Needs and/or Application: While the primary responsibility for the toxicological properties of food packaging materials is with the industrial manufacturer, basic information is needed on the migratory characteristics of standard packaging components and their biological significance in combination with edible foods. Unsuspecting substances such as PCBs may be unintentionally incorporated into the food chain through packaging materials and cause sudden havoc in the industry. As new and more diversified food industries develop in the Southern Region, this research could have a significant bearing on regional growth and stability of these

industries. The integrity of the packaged material to prevent insect contamination and the maintenance of good packaging characteristics under warm temperature and high humidity is of special concern to the Southern Region.

17. Title: Intermediate moisture foods.
SMYs 20.0 Priority 17 .

Situation: Intermediate moisture foods are identified and practiced by water activities between 0.6 and 0.9 Aw. This level of water activity provides the basis for the preservation of a limited number of foods in the market place, such as jams and jellies, pet foods, cakes, cookies and candies, etc. The requirement for foods of reduced caloric density per unit volume has stimulated interest in the development of intermediate moisture foods. The intermediate moisture food is considered to be one of the most valuable food sources for military use, small animal needs and space missions due to their small volume and weight, nutritional interchangeability and long term stability without refrigeration. The fundamentals of intermediate moisture foods and relations of water activity to microbial spoilage and enzymatic changes are a recent technology. The patent awarded the General Foods Corporation for the soft moist technology for Gainesburger Dog Food was the initial development of this technology.

Objective: To investigate the relationship of water activity levels to inhibition of growth of vegetative cells and germinating spores of microorganisms. To develop specific combinations of water controlling compounds that are both nutritionally, toxicologically and sensorially acceptable to the consuming public.

Research Approach:

a. Determine the survival of salmonella and all other food poisoning types of microorganisms at various water activities in a variety of food products.

b. Devise more rapid and precise methods of determining the water activity and its qualitative and quantitative effect upon enzymatic activity.

c. Determine the flavor and other sensory attributes related to various water activity controlling compounds in single and multiple mixtures.

Regional Needs and/or Application: This method of preservation has the potential of having great application in the warm humid Southern states.

III. Food Handling and Food Service

Food is subjected to varied manipulations and movements during its production, harvesting, processing, distribution and preparation for consumption. Many persons are involved who are intolerably deficient in their knowledge of the sanitation required to protect food from contamination with pathogens or methods for preventing the growth of microorganisms in the food. It is urgent that such persons be made aware of their responsibilities in protecting and maintaining the safety of foods; methods for transmitting such information generally are inadequate. In some instances more accurate and accelerated procedures are required to detect biological and chemical hazards in food; in others unsuspected hazards may be present for which detection methodology does not exist. Food, being an essential component of man's environment, must be available in the safest condition possible for human consumption.

1. Title: Development of new methods for the effective dissemination of existing technical information. SMYs 45.0 Priority 1 .

Situation: A critical examination of previous studies on food safety and protection indicates that lack of knowledge on proper handling of foods by producers, processors, distributors and consumers is the most important single factor contributing to foodborne illness. This also applies to market-prepared, ready-to-eat foods irrespective of the site of preparation. The problem is not a lack of technical information, but ineffective dissemination of existing knowledge and poor communication to food industry personnel.

Epidemiological studies have shown that major problems in mishandling of foods are: (a) failure to hold potentially hazardous foods at safe temperatures, (b) cooking or reheating foods at temperatures inadequate to destroy pathogens, (c) unnecessary handling of foods, and (d) contamination of foods by food handlers through poor hygienic practices or through contact with equipment and utensils that are improperly cleaned and sanitized.

Objective: To determine new approaches for the dissemination of technical knowledge on food safety to food producers processors, distributors and consumers. Improvements in the training of food service personnel could reduce the extent of foodborne illnesses in the United States.

Research Approach: A team of experts in food safety, human behavior and communication is needed to establish food safety training programs involving producers, processors, distributors and consumers. This team would study the various factors that influence the behavior and motivation of the various groups of food handlers in regard to food safety. It is recommended that they also review the recommendations of Panels 3 and 4 of the National Conference on Food Protection held in Denver, Colorado April 4-8, 1971.

Regional Needs and/or Application: The educational and training segment of food safety and protection is perhaps the greatest challenge. It is an international, national, and regional problem of great importance. In some states problems arise in food handling with groups of American citizens who have specific language and communication problems. Research on improving education and training in the basic problems of food safety and protection lends itself to a regional approach in cooperation with Food and Drug Administration Offices and the Center for Disease Control which is located in Atlanta, Georgia.

2. Title: New and improved methods for the detection of public health hazards. SMYs 35.0 Priority 2 .

Situation: The many food infections and toxemias originate in the home and in schools, canteens, hospitals, restaurants, cafes, delicatessens, social gatherings, catering, vending and other food delivery systems and other mass feeding places. There has been an enormous increase in the number of meals and meal components prepared away from home so that today almost a third of all meals are prepared outside the home and by 1980 it is estimated one-half of all meals will be prepared and eaten out of the home.

Objective: The burgeoning food service industry requires thoughtful surveillance utilizing methods that are accurate, quick, meaningful, convenient, diagnostic, reliable, and inexpensive. Improved methods should be developed that will permit detection and identification of health hazards associated with food handling in the food service industry.

Research Approach:

a. Develop new concepts for the detection of public health hazards in the food service industry.

b. Devise quick, reliable and inexpensive automated procedures for routine surveillance purposes.

c. Devise ways whereby new suspected agents may be detected in foods and provide positive control mechanisms.

d. Research is needed concerning the role, detection and control of (a) a wide array of pathogenic and toxigenic fungi, (b) certain of the Enterobacteriaceae such as the Paracolabactrums, the Bethesda, Ballerup, and El Tor groups, various Pseudomonas species, viruses, and the oncogenic viruses in particular.

Regional Needs and/or Application: Urban areas in the South are growing very rapidly--in fact, the growth of cities such as Houston, New Orleans, Atlanta and Jacksonville far exceeds the national average. As a result, phenomenal increases in public eating places and other food service facilities have taken place. Also, while the mean temperature throughout the South is more favorable for human comfort, it also provides a better climate for pathogenic microorganisms. Surveillance of the food service industry is essential and the development of procedures for reducing food infections and toxemias to a minimum must be sought.

3. Title: Safety hazards in the handling of raw foods.
SMYs 10.0 Priority 3 .

Situation: Present knowledge is inadequate to properly identify and assess public health problems attributable to raw foods. Production practices utilized for these commodities cause them to be suspect and indicate that greater hazard may be involved than has been identified. Also, renewed interest in home gardening and utilization of home grown products may increase these hazards.

Objective: A careful appraisal should be made of the risks associated with (1) the presence of Enterobacteriaceae and oncogenic viruses from human and animal sources and (2) microbial contamination that accrues during production and distribution and (3) development of chemical toxicants during particular storage conditions.

Research Approach:

a. Survey and identify the biological and chemical hazards in raw foods caused by handling methods.

b. Study handling procedures that cause the presence of hazards in specific raw foods.

c. Design new or corrective handling procedures to prevent the addition of biological contaminants, or the development of chemical toxicants in raw foods.

d. Develop procedures to treat raw foods for inactivation of biological agents.

e. Study packaging procedures and materials to protect foods from contamination by microorganisms or from development of chemical toxicants.

Regional Needs and/or Application: Information is needed on the extent of specific hazards which may exist on raw foods (i.e., nutmeats, celery, cabbage, carrots) contaminated during harvesting, packaging, and distribution. Owing to existing production practices, exposure of foods to microbial pathogens of human or animals can occur--often in an unsuspected manner. By the proper adaptation of existing technology or engineering expertise it is likely that such hazards could be prevented from occurring. Such expertise would include devising automated equipment that would be completely sanitary.

4. Title: Control food safety hazards in processed products which result from handling practices during and after processing.
SMYs 30.0 Priority 4 .

Situation: Most current commercial food processing operations use containers and materials which may become heavily contaminated with microorganisms unless treated with sanitizing agents including anti-microbial chemicals during processing or after the final products are produced. Pathogenic microorganisms may be incorporated into the product from personnel, equipment or contact materials involved in sorting, grading and other processing operations and may persist in frozen and other non-sterile products. Hazards which may arise during processing or handling of the processed product include physical damage to packages, holding at improper temperatures, contact with contaminated surfaces and other general abuse of the product. Research is needed to develop optimum procedures for processing and handling of food products to insure their wholesomeness when delivered to the consumer.

Objective: To reduce or eliminate safety hazards in processed foods resulting from improper processing steps or handling practices during storage, transport and distribution of the product to assure wholesome products at consumption.

Research Approach:

a. Establishment of relative effectiveness of containers and chemical additives in preventing microbial growth in raw materials incorporated into non-sterilized food products, in the processes involved in forming the product and in storage and distribution of the products. These studies would include prevention of toxic or potentially dangerous chemical substances from becoming incorporated into the product.

b. Evaluate food processes, storage, and distribution systems for critical control points (CCP) to insure adequate sampling to minimize the degree of risk of unwholesome products reaching the consumer. This includes studies to locate CCP's based on sensitive ingredients, pasteurization or microbiological evaluation and abuse potential of the product. Such CCP's when reliably identified and determined to be negative should provide food processors and consumers with maximum confidence that the product is uncontaminated.

c. Development and evaluation of handling procedures for maintaining product and container integrity of processed foods to produce safe products. These studies would include treatment of product and container, development of product handling and distribution systems, and development of objective indicators of product abuse.

Regional Needs and/or Application: With the continuing replacement of human labor with machines, handling practices during and after processing must be evaluated to reduce the development of pathogens, thus insuring food safety. In the Southern Region there is a predominantly less experienced labor force making use of transient and imported labor, that may result in problems due to inadequate product handling during processing and distribution. Machine operators are frequently unaware of the principles of food safety when handling or distributing bulk quantities of products. In the Southern Region there have been recent trends toward increasing production of seafood items and ethnic foods. Both of these food product areas require special care, knowledge and experience to avoid unwholesome products due to abuse during processing and storage.

5. Title: Viruses in foodstuffs. SMYs 10.0 Priority 5 .

Situation: It is well established that foods can serve as a vehicle for dissemination of disease producing viruses; i.e., polio and infectious hepatitis. Epidemiological studies of a number of outbreaks have implicated such foods as shellfish and other raw and prepared foods. Even though it is known that virus infections can be transmitted by foods, our available knowledge, methodology and personnel are woefully inadequate to assess the magnitude of this problem.

Objective: To determine if infectious viruses are present in our food supply and, if so, do they present a health hazard.

Research Approach:

a. To develop procedures for the enumeration, isolation and characterization of viruses in foods.

b. To survey market foods for the presence of infectious viruses and determine if a relationship exists between the incidence of disease and the presence of the specific viral agent in a food supply.

c. To establish the initial source of the virus and its mode of entrance into the food or food chain.

d. To determine the effect of individual food constituents on inactivation of viruses.

e. To develop procedures that eliminate viruses from foods or methods which will inactivate them during processing.

Regional Needs and/or Application: Determining the possible role of foods in the transmission of viruses is of world-wide concern. Many factors existing in the South could conceivably contribute to the problem. The use of more highly processed foods, recycling of plant wastes and effluents, contaminated ground water supplies and estuaries and their effect on the food supply need to be fully investigated.

IV. Mycotoxins

Mycotoxins impose a potential nationwide hazard in foods and feeds. Initially, most research was directed to aflatoxin contamination in peanuts and cottonseed, but recent research has involved the natural occurrence of aflatoxin and other mycotoxins in corn, rice, tree nuts, apples, celery, sweet potatoes, aged cured meats, barley, other grains, milk products, and mixed feeds. Other mycotoxins are produced by Claviceps spp. (ergotoxine, ergotamine) in grasses, Fusarium spp. (zearalenone, diacetoxyscirpenol) in corn, millet, other grains, and fescue, Penicillium spp. (citrinin, citreoviridin, cyclopiazonic acid, islanditoxin, luteoskyrin, patulin, penicillic acid, rubratoxin, viridicatin) in foods and feeds, Rhizoctonia leguminicola (slaframine) in red clover, Pithomyces chartarum (sporidesmin) in grasses and Sclerotinia sclerotiorum (psoralens) in celery causing photosensitization, and Aspergillus species (ochratoxin, A. wentii toxin) in feedstuffs.

Aflatoxin as it relates to peanuts is the most thoroughly investigated mycotoxin problem. The cooperative effort between industry and Federal and State agencies has been successful in assuring the American consumer of the safety of peanut products and may well serve as a model for research on other mycotoxins in various foods. Initially, a statistically designed survey was made to determine the incidence of aflatoxin contamination in U. S. peanuts. Methods were devised to minimize sampling error and methodology was evolved for the accurate, sensitive, and rapid detection of aflatoxin. Aflatoxin standards were distributed for national and international collaborative evaluation of analytical methodology. Limiting environmental conditions for the elaboration of aflatoxin were determined. Research to seek genetically resistant strains is continuing. Harvesting procedures that minimize contamination of the crop have been devised. Methods have been developed for detecting and removing contaminated kernels and to remove or destroy aflatoxin in contaminated peanut products. Metabolism and metabolic fate of aflatoxins in certain animal systems have been investigated, and metabolic degradation products, e.g. aflatoxins M_1, P_1, and Q have been identified.

A similar approach needs to be carried out in investigations of fungal contamination and mycotoxin formation in other agricultural commodities, processed foods, and finished feeds.

1. Title: Aflatoxin and related mycotoxins in processed food products.
SMYs 50.0 Priority 1 .

Situation: Aflatoxin B_1 and other aflatoxin-related compounds are produced by fungi of the Aspergillus flavus group. Other species of the genus Aspergillus have been implicated as possible sources of these compounds. Sterigmatocystin was first found as a product of A. versicolor, but later A. flavus, A. nidulans, and Bipolaris sp. were reported to produce this compound. These mycotoxins have been shown to be potent carcinogens and their detection in food products can lead to condemnation and seizure.

Environmental conditions favorable for the development of contamination with aflatoxins and related mycotoxins commonly prevail throughout the South. Southern crops such as corn, rice, peanuts, and cottonseed are known to be excellent substrates for growth of the fungi producing these mycotoxins. Moreover, aflatoxin contamination in peanuts annually forces the diversion of large quantities from processing for food use to oil seed stocks with the meal being diverted to fertilizer, a resulting loss of value to the industry and of high protein food resources. Mycotoxin contamination has also been reported in corn, rice, and cottonseed. Because of aflatoxin contamination, the FDA has recently condemned several large lots of white corn being processed for food use in the South. High levels of aflatoxin contamination also occur regularly in cottonseed in certain areas of the U. S. and contamination has also been reported in rice.

About 350 million bushels of corn are processed annually for human consumption, but little is known about the fate of mycotoxins during processing into breakfast foods, corn meal chips, tortillas, hominy, grits, etc. Similarly, the effect of processing other cereals on the mycotoxins they may contain has not been clearly elucidated. Although the fate of aflatoxins during the processing of peanuts has been extensively investigated, the effect of processing on related mycotoxins is not known. The processing of cottonseed into a high protein flour for fortifying food products has now become a commercial reality, indicating the need for emphasis on the investigation of the fate of mycotoxins in such products.

Objectives: Insure that processed foods will be free of aflatoxin and related mycotoxins by: Developing methods suitable for rapid detection of mycotoxins in food crops during plant operations; determining the fate of mycotoxins during processing through the various stages to the final product; and devising methods to remove or destroy mycotoxins during processing.

Research Approach:

a. Investigate and adapt present, or develop new methods for rapid detection of aflatoxins and related mycotoxins in raw food products and during the various stages of processing.

b. Determine the fate of mycotoxins from the contamination of the raw product through various stages of processing to the final product.

c. Investigate the effect of chemical additives and of mechanical operations on destruction or detoxification of mycotoxins.

d. Devise physico-chemical methods for removing mycotoxins from raw products or during processing.

e. Determine the conditions under which mycotoxin contamination can occur during processing or in the final product.

f. Devise guidelines to prevent mycotoxin contamination in all phases of food processing.

Regional Needs and/or Application: Contamination of food crops with aflatoxin and related mycotoxins is a major problem in the South where sub-tropical climates prevail. The fungi producing these mycotoxins are ubiquitous throughout the region and attack most food crops or products. Edible corn products such as corn meal, flour, grits, hominy, tacos, etc. are primarily produced and consumed in the South as is the production and processing of rice, cottonseed, and peanuts. An educational program for farmers and processors regarding the hazards and control of significant fungal contamination in these crops is needed.

2. Title: Aflatoxin and related mycotoxins in livestock and poultry feeds.
SMYs 50.0 Priority 2 .

Situation: The presence of aflatoxin in corn and other crops has serious implications for the swine, cattle, and poultry industries. Corn makes up a large percentage of the diet of livestock with the trends being toward confined and concentrated operations. Aflatoxicosis in livestock may be expressed in high mortality of very young animals, reduced feed conversion, serious retardation of growth and weight gains at sublethal levels of toxin, and gross liver damage including cirrhosis and impaired hepatic systems depending upon the species of animal involved. In cattle and swine, aflatoxin may appear in the milk as highly toxic aflatoxin M. In poultry, decreased egg production and egg hatchability occurs. Sterigmatocystin is another very carcinogenic metabolite occurring in feeds that is produced by several species of Aspergillus, Bipolaris sp., and Penicillium luteum. This mycotoxin may prove to be as big a threat in corn as aflatoxin. Aspertoxin and O-methylsterigmatocystin are related toxic metabolites.

Objectives: Determine the incidence and significance of aflatoxin and sterigmatocystin contamination in livestock feeds, particularly in corn and oilseed meals; determine the biological effects of aflatoxin and sterigmatocystin on different breeds and ages of livestock, and develop methods for prevention and control of toxicity due to aflatoxin and sterigmatocystin in poultry, swine, and cattle.

Research Approach:

a. Research similar to that dealing with aflatoxin in peanuts is recommended beginning with a statistically designed survey to determine the incidence of aflatoxin contamination (and that of related mycotoxins) in corn and livestock feeds and its implication to the several industries.

b. Adapt data on sampling, standards, and limiting environmental conditions for the elaboration of aflatoxin in peanuts to harvesting procedures to minimize contamination of corn, other feed ingredients, and finished feeds.

c. Short term and long term feeding studies should be conducted with different ages and breeds of livestock to more precisely determine the biological effects of aflatoxin.

d. Distribution and fate of aflatoxin and related mycotoxins in the animal should be investigated.

e. Develop methods for early detection of aflatoxicosis and for detoxification of feeds, prevention, and control.

Regional Needs and/or Application: A regional project is recommended. The poultry, swine, and cattle industries are large, important growth industries in the South. The presence of aflatoxin, sterigmatocystin, and other mycotoxins in corn, other feed grains, and in finished livestock feeds has serious implications for livestock. The trend is toward confined and concentrated operations with poultry, swine, and cattle. Low grade corn, most of which is shipped in from the Midwest, is a particular source of hazard. Such corn is stored for varying lengths of time both before and after shipment to the South. Grain moisture may vary widely during shipment by river barge and during storage in fluctuating temperatures and relative humidities, thus subjecting the corn to invasion by toxigenic fungi. The broad extent of the hazard of aflatoxin and related mycotoxins to the Southern poultry, swine, and cattle industries is gradually being recognized. Evidence indicates that major research on this problem is warranted.

3. Title: Mycotoxin methodology.
SMYs 80.0 Priority 3 .

Situation: A considerable number of mycotoxins elaborated by a spectrum of fungi proliferating on agricultural commodities have been identified as potential health hazards to animal and man. Continuing research in the mycotoxin area will certainly uncover as yet unknown toxins.

Evaluation of the degree of mycotoxin contamination in foods and feeds requires reliable sampling techniques, rapid detection methods, accurate and sensitive quantitative methods, and authentic primary standards. Reliable procedures for sampling commodities for heterogenously distributed mycotoxins is an area that has received little attention. Rapid detection methods (15 min. or less), comparable to those developed for B and G aflatoxins, are needed for other mycotoxins. With the exception of B and G aflatoxins, aflatoxin M_1, and ochratoxins, quantitative methodology for other mycotoxins is either in an early stage of development or is nonexistent. Except for B and G aflatoxins, aflatoxin M_1, ochratoxins, patulin, penicillic acid, rubratoxin B and sterigmatocystin, authentic primary standards of other mycotoxins are not readily available.

The metabolic fate of ingested aflatoxins in animal species has received attention only in case of aflatoxin B_1 where biologically altered analogs such as aflatoxins M_1 and M_2, P_1, Q, aflatoxicol, and parasiticol have been identified. Very little is known of the metabolic fate of other mycotoxins. Except in the case of aflatoxin M_1, reliable methods to detect and determine metabolically altered mycotoxins in animal tissues, organs, and edible products are lacking and are much needed.

Inactivation and detoxification of mycotoxins in agricultural products requires knowledge of the compounds, produced, methods to detect and determine such compounds, and assurance that the nutritional quality of treated materials is not impaired. Work in the area of mycotoxin inactivation chemistry and the nutritional evaluation of inactivated products is urgently needed.

Relatively simple bioassay techniques, comparable to the fertile egg embryo, Bacillus megaterium, or brine shrimp bioassays for aflatoxin B_1, are needed for other mycotoxins. Such techniques would reinforce quantitative assays, minimize the use of costly animal feeding studies, and aid in the determination of harmful mycotoxin levels in foods and feeds.

Production or nonproduction of mycotoxins by wild fungal species, and concomitant production of both mycotoxins and hydroxyanthraquinone pigments by mutant strains undoubtedly involve specific enzyme

systems necessary for biosynthesis of mycotoxins. Methods need to be developed or adapted to investigate the enzyme systems involved in the formation and inhibition of mycotoxin synthesis. The effects of environmental conditions on the production of mycotoxins need to be established.

Objectives: Develop accurate techniques for sampling commodities for mycotoxin contamination; develop accurate and sensitive methods for detecting and determining mycotoxins; develop techniques for preparing primary standard quality mycotoxins and criteria for establishing their purity; develop information needed to aid in preventing mycotoxins elaboration in agricultural commodities; develop processes to inactivate mycotoxins and identify compounds produced by inactivation treatments; determine the metabolic fate of mycotoxins or their inactivated products ingested by animals; devise simple bioassay techniques for mycotoxins; and determine the enzymes involved in the synthesis of mycotoxins by toxigenic fungi.

Research Approach:

a. Devise and evaluate statistically designed techniques for reliable sampling of food and feeds for the presence of mycotoxins, and design simple low-cost sampling equipment or system.

b. Develop rapid, simple, and sensitive screening methods to detect mycotoxin contamination in foods and feeds.

c. Develop accurate and sensitive methods to determine mycotoxins in foods and feeds.

d. Develop techniques for preparing primary mycotoxin standards and establish criteria for determining their purity.

e. Investigate environmental conditions such as light, gases, moisture, and temperature and chemicals that limit the production of mycotoxins.

f. Develop information needed to aid prevention of mycotoxin elaboration in agricultural commodities.

g. Determine fate of mycotoxins ingested by animals, identify metabolic products, and determine amounts deposited in edible tissues, organs, and animal products.

h. Develop practical processing methods to inactivate mycotoxins in foods and feeds by treatment with chemicals, or to detoxify by removal of mycotoxins by phsico-chemical means.

i. Characterize compounds produced in inactivation and detoxification of mycotoxins in contaminated foods and feeds, devise methods for their detection and estimation, and establish stability, safety and nutritional quality of inactivated products.

j. Devise simple bioassay methods to establish toxicity and harmful levels of mycotoxins in foods and feeds.

k. Devise techniques to identify specific fungal enzyme types and correlate with production of mycotoxins and hydroxyanthraquinone pigments.

Regional Needs and/or Application: Food crops in the South are attacked by a spectrum of fungi that elaborate a number of mycotoxins. Dominance of fungal species varies with the crop and consequently the types of mycotoxins vary with the crop. Research proposed can be used to survey crops of the Southern Region to determine the types of mycotoxins, contamination, and incidence. When mycotoxin contamination is found to be of concern, liaison should be set up with food and feed processors to institute measures to remove contaminated crops from the food and feed chain. An educational program to inform food and feed processors of the potential health hazards of mycotoxin contamination is also recommended.

4. Title: Detection and control of aflatoxin and other mycotoxins in tree nut crops.
SMYs 15.0 Priority 4 .

Situation: Approximately 276 million pounds of pecans with a farm value of about 114 million dollars were produced in 9 Southern States and New Mexico in 1973. Some samples of domestic pecans have been found to contain in excess of 20 ppb of aflatoxin, the current FDA tolerance guideline. The FDA has stated that the pecan industry has a potential problem and they will survey pecans in the market for mycotoxins. Methods for the detection and determination of aflatoxins in pecans are available, but little scientific data are available concerning the presence of other mycotoxins or toxin-producing fungi in pecans.

Objectives: Determine incidence of aflatoxin and other mycotoxin contamination in tree nut crops; determine limiting environmental conditions for the development of mycotoxins in nut crops to prevent or minimize production of mycotoxins during harvesting, handling, processing and storage; devise methods to prevent contamination with mycotoxins and to remove contaminated nuts is contamination occurs.

Research Approach:

a. Conduct a statistically designed survey of pecan lots in storage, and assay them for aflatoxin or other mycotoxins to determine incidence and severity of such contamination by location and grade.

b. Determine limiting environmental conditions of temperature and moisture (relative humidity) for the production of aflatoxin and other mycotoxins in pecans, almonds, Brazil nuts, and Persian (English) walnuts during harvest, storage, handling, and processing.

c. Study effects of current commercial harvesting, handling, and processing practices on mycotoxin contamination of pecans and devise methods to prevent or minimize contamination when it occurs.

d. Correlate mycotoxin contamination with observable differences such as observable mold, gross defects, and cracked or discolored nuts.

e. Develop mechanical means for separation of contaminated nuts, as by sizing, air aspiration, and electronic or hand sorting.

f. Determine the mycoflora of sound and contaminated pecans.

Regional Needs and/or Application: Although marketed nationally, most pecans are produced in the Southern Region, especially in Texas, Georgia, Alabama, Louisiana, and Mississippi, and aflatoxin problems are most commonly noted in tropical and sub-tropical climates that are prevalent in these areas of production.

5. Title: Mycotoxins in milk, cheese, and aged cured meats.
SMYs 15.0 Priority 5 .

Situation: When lactating mammals are fed aflatoxin-contaminated feeds, they excrete in their milk toxic metabolites, aflatoxin M_1 and M_2. Samples of retail milk in South Africa have been found to contain aflatoxin M. A survey by FDA of milk products in 18 states indicated aflatoxin M_1 to be present at low levels in about 7% of the samples. If M_1 contaminated milk is treated with rennet, the precipitated fraction (casein with some fat) contains most of the aflatoxin M_1. Thus, cheese and butter are potential sources of aflatoxins in the diet. The pooling of bulk milk may dilute contaminated milk from individual herds, but in areas where production and consumption are localized, milk and milk products, such as nonfat dry milk, evaporated and condensed milk, and cheeses, are a potential source of human exposure to aflatoxins. Cheese may become contaminated with fungi during aging resulting in formation of mycotoxins at this stage. Other toxin-producing fungi have been isolated and additional mycotoxins such as sterigmatocystin, ochratoxin, citrinin, patulin, and Penicillium toxins may be also involved. Meat products such as salami, bacon, and country-cured hams may become contaminated with aspergilli and penicillia during curing or subsequent storage and these fungi can produce mycotoxins on these substrates under laboratory conditions.

Objective: Determine the incidence of mycotoxin contamination in aged cured meats, milk, cheese, and/or other food products prepared or held under specified conditions and relate these findings to chemical, microbiological, and environmental factors.

Research Approach: A regional project is recommended:

a. Survey ham processing plants using the Smithfield type or country-cured process to determine the incidence of mycotoxin contamination of aged hams and bacon; and identify the fungi present.

b. Conduct a statistically designed survey of aged and/or moldy cheeses and assay representative samples for incidence of mycotoxin contamination, and identify the fungi present.

c. Survey fluid milk and milk products to determine incidence of aflatoxin M_1 contamination; relate to contamination of cattle feed.

d. Study processing, handling, and storage conditions that result in mycotoxin contamination of milk, cheese, and aged cured meats.

Regional Needs and/or Application: Country-cured hams and bacon are very popular in Southern United States, but they are potential sources of mycotoxins. The hams and bacon are often produced in small plants, which lack the capital and expertise to solve mycotoxin problems. High humidity conditions, which prevail in the South, make the problem especially acute. Milk and milk products are also potential sources of mycotoxins.

6. Title: Fusarium mycotoxins in corn and other livestock feeds in the South. SMYs 30.0 Priority 6 .

Situation: Field and storage conditions during the fall of 1972 resulted in Fusarium infection of corn in northern Indiana, Ohio, and southern Michigan. An appreciable amount of this corn was shipped to the South for livestock feed and caused large economic losses in animals from the mycotoxins, zearalenone (F-2) and epoxytrichothecenes. In addition, an aromatic substance, refusal factor, was produced that resulted in poor weight gains, since hogs refused to eat contaminated corn. Zearalenone, an estrogenic mycotoxin responsible for outbreaks of abortion and vulvovaginitis in swine, also affects the development of turkeys and chickens. Twenty-two naturally-occurring trichothecenes produced by five species of Fusarium and five other species of fungi are presently known, some of which are antibiotic, some phytotoxic, and some cause diverse biological effects on various animals, insects, and humans. Small amounts of diacetoxyscirpenol and T-2 frequently present in moldy corn, recently have been implicated in emesis in swine and is a component of the cause of alimentary toxic aleukia (ATA), which has killed many people in Russia when it was produced by Fusarium on overwintered millet, wheat, and barley. The list of diseases that may be attributable to Fusarium toxins includes fescue foot in cattle and moldy corn toxicosis.

Objective: Determine the incidence, severity, and significance of Fusarium-toxin contamination in animal feed, especially in corn, as it relates to the swine, poultry, and cattle industries.

Research Approach:

a. Conduct a statistically designed survey to determine the incidence of Fusarium contamination in poultry, swine, and cattle feed.

b. Isolate individual Fusarium species, culture on sterilized feed, and determine their biological activity by short and long term feeding studies.

c. Observe disease syndromes where appropriate, isolate and identify the mycotoxins, and develop techniques for quantitative determination.

Regional Needs and/or Application: The estrogenic syndrome in swine has been observed periodically in the South. However, it is not clear whether zearalenone is responsible for this syndrome in the South. Evidence warrants research to determine the extent of the hazard of the several mycotoxins from Fusarium spp. to the swine, poultry, and cattle industries relative to the use of high levels of corn and other grains in confined and concentrated

animal feeding operations. Improved methodology for analysis of food and feeds for zearalenone is needed.

7. Title: Pencillium toxins in foods and feeds.
SMYs 40.0 Priority 7 .

Situation: Many species of the genus Penicillium have been found to produce more than 25 toxic or antibiotic metabolites in food and feed. The organisms are prevalent in agricultural products ranging from stored seeds and milled products to prepared foods such as cured meats and cheese. P. citreo-viride in yellowed rice was first associated with a nervous disease causing death in laboratory animals and later implicated in death and/or the development of beriberi-like symptoms in man. Toxins produced by other penicillia in the yellowed rice syndrome include luteoskyrin, islanditoxin, cyclochlorotine, erythroskyrine, and rugulosin, which are hepatocarcinogenic to laboratory animals. Citrinin, produced by 8 Penicillium species, have severe renal toxicity capabilities. P. cyclopium produced a tremorgenic-diuretic toxin in moldy corn that killed sheep and horses. Penicillic acid, produced by at least 10 species, is an hepatic toxin associated with "blue-eye disease" of corn that has caused death to livestock and poultry. P. expansum and other penicillia elaborate patulin. Other Penicillium toxins include rubratoxin B, tremortin A, viridicatin, mycophenolic acid, and cyclopiazonic acid. Thus, toxic metabolites of the fungus Penicillium are capable of causing a wide variety of toxicoses. Some toxins are carcinogenic, some are lethal at low levels, while others require large doses to produce observable symptoms. They cause nervous disorders; respiratory paralysis; and lesions to spleen, kidneys, or liver. The full significance of these toxins to the health of man and animals need to be ascertained.

Objective: Determine the incidence and significance of Penicillium toxin contamination in food and feed produced or consumed in the Southern Region.

Research Approach:

a. Survey food and feed in the Southern Region to determine the prevalence of contamination and the species of penicillia.

b. Isolate species of Penicillium to pure culture; grown on natural and/or semisynthetic media; determine toxicity by bioassays; and isolate and identify the toxic metabolite or metabolites.

c. Determine biological effects of each toxin by long and short term feeding of experimental and domesticated animals.

d. Develop rapid and reliable methods for assaying food and feed for each toxin.

e. Survey food and feed produced or consumed in the South to determine the significance of individual toxins.

f. Develop methods to prevent contamination of foods and feeds with Penicillium toxins or to facilitate their removal or detoxification.

Regional Needs and/or Application: The climatic conditions of the Southern Region are often favorable for the infestation of food and feed by fungi. The penicillia include species capable of growing over a wide range of climatic conditions; however, toxin production may occur only in a narrow range and on certain crops or products. The South produces and consumes a multiplicity of foods and feeds. Currently, data regarding the interrelation in the South between the penicillia, the climate, and the substrates are scarce.

8. Title: Patulin in food and feed products.
SMYs 15.0 Priority 8 .

Situation: Patulin, a fungal metabolite that may occur in fungal-contaminated foods, particularly fruit juices, flour, cured meats, and animal feeds, has been reported to be a carcinogen when injected subcutaneously. Patulin is mutagenic, causes chromosome damage in biological systems, and high concentrations result in acute toxicity and death. This fungal toxin is produced by 10 species of the genus Penicillium, 3 species of Aspergillus, and several species of Byssochlamys (Paecilomyces). P. expansum is a common storage rot of apples and other fruit, and patulin has been found in commercial samples of apple juice. The production of patulin by P. expansum in meat products has been demonstrated. Refrigerated storage does not prevent patulin in foods, since research shows that some Aspergillus and Penicillium species produce considerable amounts of toxin at temperatures below 2 C. Patulin has also been isolated from molded bread and bakery goods. Patulin-producers such as A. clavatus, A. terreus, and P. urticae have been isolated from flour. Byssochlamys nivea is a heat-resistant fungus contaminating fruit juices. Two patulin-producing strains of P. patulum were isolated from chick starter rations. In addition, P. urticae, a known patulin producer, was isolated from malt feed, which had caused the mass death of cows in Japan. Patulin is produced by many species of fungi on a wide range of agricultural commodities. The significance of its presence to human health needs to be further evaluated.

Objective: Determine the range of commodities susceptible to patulin-producing fungi and the incidence and levels of patulin produced in these commodities by various methods of harvest, processing, and storage.

Research Approach:

a. Study the production of patulin by fungi in various agricultural commodities.

b. Study the effects of processing and storage on patulin concentration in various contaminated agricultural commodities.

c. Evaluate the effects of patulin on living organisms, especially the ingestion of subacute levels over long periods.

Regional Needs and/or Application: Fruit, grains, and cured meat products are all produced in this region. Environmental conditions that prevail in the South favor proliferation of fungi a number of which produce patulin. Patulin has been implicated in death or decreased production efficiency of livestock and poultry because of the presence of patulin-producing molds in the feed.

9. Title: Furanoterpenoid toxins in sweet potatoes.
SMYs 20.0 Priority 9 .

Situation: Sweet potatoes may be contaminated with furanoterpenoid toxins from the presence of mold infestation, certain chemicals, insect penetration, and mechanical damage during harvesting, processing, or storage. Ipomeamarone appears to be the predominating compound, but is sometimes accompanied by the related toxins ipomeamaronol, 1,4-ipomeadiol, 1-ipomeanol, 4-ipomeanol, and ipomeanine. Although no information is available on the effects of ingestion of ipomeamarone and other sweet potato toxins by humans, limited studies with experimental animals have shown that some are liver toxins, while others produce lung damage and respiratory disease similar to that seen in natural outbreaks of poisoning in cattle caused by ingestion of mold damaged sweet potatoes. Since most sweet potatoes are consumed as food, these toxins could pose a serious human health hazard. Therefore, a survey of the incidence of ipomeamarone and other furanoterpenoid toxins in fresh and cured marketable sweet potatoes and sweet potato products is urgent to establish a basis for diverting contaminated sweet potatoes from the food chain.

Objectives: Develop procedures for the detection and quantitative determination of furanoterpenoid toxins in sweet potatoes and their products; determine the incidence and significance of furanterpenoid toxins in sweet potatoes and their products; devise methods for the prevention and control of furanoterpenoid toxins in sweet potatoes and their products; and devise methods for the elimination or inactivation of furanoterpenoid toxins in diseased or blemished sweet potato peelings and/or trimmings.

Research Approach:

a. Improve available methodology for the quantitative determination of ipomeamarone and develop sensitive and accurate analytical procedures for the detection and quantitative determination of the other furanoterpenoid toxins.

b. Determine the incidence of furanoterpenoid toxins in fresh, cured, damaged, diseased, and processed sweet potatoes of different varieties.

c. Determine the effects of peeling and trimming on the removal of furanoterpenoid toxins from raw and cooked contaminated sweet potatoes.

d. Investigate the effects of processing and storage on the presence of furanoterpenoid toxins in sweet potatoes and their products.

e. Develop techniques for the elimination and/or inactivation of ipomeamarone and other furanoterpenoid toxins in sweet potato peelings and trimmings.

f. Determine the degree of toxicity and biological effects of furanoterpenoid toxins and their derivatives to animal species.

Regional Needs and/or Application: Sweet potatoes rank third in farm value for vegetables crops grown in the Southern States. The presence of ipomeamarone and other furanoterpenoid toxins in sweet potatoes has serious implications for the industry and for human health. Evidence indicates that research is needed to correlate content of ipomeamarone and other toxins with variety of sweet potato, type of sweet potato disease or damage. Rapid and efficient analytical procedures are needed for the detection and quantitative determination of these toxins. A survey is needed of the incidence of these toxins in fresh and cured marketable sweet potatoes and in processed sweet potato products.

10. Title: Phototoxins in vegetables and grasses.
SMYs 10.0 Priority 10 .

Situation: Several mycotoxins promote phototoxic diseases that affect both humans and animals. Facial eczema is a photosensitization disease, principally of sheep in New Zealand and of cattle in Australia, that is caused by the fungus Pithomyces chartarum, when it saprophytically colonizes dead herbage or litter. The toxin sporidesmin is one of the epipolythiadioxopiperazines, which are toxic metabolites produced by several other soil fungi. Although this disease has not been found in the U.S., the fungus has been found in Texas. Also, a disease, strikingly similar to facial eczema, was reported in cattle grazed on moldy Bermudagrass in the Southeast; the predominating fungus was Periconia minutissima. However, workers failed to isolate the toxic principle. In 1971, 25,000 cattle in Louisiana and Mississippi were afflicted with "staggers" or tremors associated with moldy Bermudagrass. The cause and toxin were not demonstrated.

Several psoralen (furanocoumarin) mycotoxins are toxic, although none of the psoralen compounds produced under natural conditions by healthy celery plants have had detrimental effects on animals or humans. However, celery diseased by Sclerotinia sclerotiorum (pink rot) causes blistering lesions on workers harvesting celery infected by this fungus when skin is exposed to UV (sun). Xanthotoxin (8-methoxysporalen) and bergapten (5-methoxyposoralen) have been isolated from diseased celery causing phototoxicity.

Objectives: Determine the causal fungus and toxin of the Bermudagrass toxicosis in Southeastern United States; determine the incidence of Sclerotinia scleriotiorum infection and the levels of phototoxins produced on celery and other edible plants in the field; develop preventive and control measures for phototoxins in Bermudagrass pastures and in celery and other vegetables.

Research Approach:

a. Design statistically-based surveys to determine the incidence of phototoxins in Bermudagrass pastures and in celery and vegetables.

b. Determine if S. sclerotiorum and/or phototoxic fungi are common to other vegetables and pasture grasses and, if so, the economic, public, and animal health significance of this occurrence.

c. Investigate the metabolic activity of the causal fungus (i) of Bermudagrass toxicosis and of S. sclerotiorum to determine under what conditions phototoxins are produced. Evalute the relation between various harvesting, processing, handling, and storage practices to the level and occurrence of phototoxins in vegetables and grasses.

Regional Needs and/or Application: A regional project is recommended. Bermudagrass is one of the major forages in the Southeast and droughts and frosts frequently create conditions favorable for the development of saprophytic fungi that may produce phototoxins under warm humid conditions. Celery requires a rich loamy soil and large quantities are grown in Florida and several other states in the South.

11. Title: Ochratoxins and related mycotoxins in foods and feeds. SMYs 10.0 Priority 11 .

Situation: Ochratoxin A is a toxic metabolite produced by Aspergillus ochraceus, Penicillium viridicatum, and other fungi. It was originally isolated from corn in South Africa. Production of ochratoxin frequently accompanies that of penicillic acid, another carcinogenic mycotoxin. Canadian workers have found ochratoxin occurring naturally in wheat, oats, barley, peanuts, beans, and mixed feed grains probably from contamination by P. viridicatum. Also, toxin-producing strains of A. ochraceus have been isolted from aged, cured meats and from numerous other foods by several workers.

Objective: Determine the incidence and economic importance of ochratoxin A and related dihydroisocoumarins in agricultural commodities, foods, and feeds.

Research Approach: Surveys of cereals, legumes, country cured hams, mold fermented sausages, and other processed foods and feeds need to be made and samples chemically analyzed for the presence of ochratoxin A and other dihydroisocoumarins to determine the possible economic threat of these mycotoxins to human and animal health.

Regional Needs and/or Application: Aspergillus ochraceus, related fungi of the A. ochraceus group, and ochratoxin-producing species of Penicillium are common in the Southeast. Environmental conditions are also favorable for their development in agricultural commodities.

12. Title: Mushroom toxins.
SMYs 10.0 Priority 12.

Situation: Although mushroom poisonings usually make up less than 2% of the poisonings reported to the National Clearing House for Poison Control Centers, nine people died in the U.S. in 1972 from mushroom poisoning. In 1967-68, there were 675 cases of mushroom poisoning with no fatalities. The white or green species of Amanita usually cause about 90% of fatal mushroom poisonings. Some mushrooms may also be hallucinogenic and, when eaten accidentally or deliberately, may cause far-reaching deleterious effects to man or animals. In many cases the nature of the chemical compounds are unknown.

Objectives: Determine the incidence of known poisonous and hallucinogenic mushrooms in the South; isolate and idenfity the metabolites present in known poisonous and hallucinogenic mushrooms and other common mushrooms that might be collected and eaten by man, and determine the effects of mushroom metabolites on experimental animals.

Research Approach:

a. Carry-out surveys for the occurrence and identification of mushrooms in the South.

b. Where large collections of a variety of fungi can be obtained, chemical extractions of metabolites are to be carried out. The resulting metabolites would be isolated, identified, and related chemically to known toxic or hallucinogenic compounds.

c. The biological effects of mushrooms, crude extracts, and pure compounds would be investigated in rats and/or other experimental animals.

Regional Needs and/or Application: A regional research program is recommended as an interdisciplinary approach may be necessary as there are mycological, chemical, and toxicological aspects to the problem. About 40-50% of the acreage in the South is in forests. The taxonomy of mushrooms is difficult and positive identification requires expertise. Additional mycological research is needed on mushrooms in the South. Due to the high rainfall, attendant relative humidity, and warm temperatures, mushrooms are plentiful in the fields and forests of the region.

Summary of Food Safety and Protection Research in the Southern Region (FY 1973).[1]

Research Area	SMY's
I. Food Protection (Production)	
A. Soil and Water	23.3
B. Toxicants in Food and Feed	11.4
C. Aquatic Foods	3.7
II. Food Processing and Manufacturing	
A. Unit Operations	15.3
B. Product Safety	12.8
C. Preservation	8.4
III. Food Handling and Food Service	21.7
IV. Mycotoxins	10.2
Total	106.8

[1]Table was developed from information retrievals from the Current Research Information System. Mycotoxin data obtained 4-22-74.

Summary Table of RPA's with SMY's

RPA's	SMY's		
	Current Level	10% Increase	Recommended Level
I. Food Protection (Production)			
213			2
701	10	11	122.8
702	4	4	50
703	1	1	4
707	1	1	10
901	6	7	80.2
Total	22	24	269
II. Food Processing and Manufacturing			
701	15	17	180
702	29	31	350
Total	44	48	530
III. Food Handling and Service			
701	2	2	22
702	2	2	23
703	4	5	45
704	1	1	30
707	1	1	10
Total	11	12	130

Summary Table of RPA's with SMY's

	SMY's		
RPA's	Current Level	10% Increase	Recommended Level
Mycotoxins			
702	29	32	345
Grand Total	106	116	1274